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COTTON FLOWER AND BOLI

PITMAN'S COMMON COMMODITIES
OF COMMERCE

COTTON

FROM THE RAW MATERIAL TO THE FINISHED PRODUCT

BY

R. J. PEAKE

REVISED EDITION

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PREFACE

Owing to the regrettable death of the Author of this book, it was necessary to invoke other aid. The last two chapters of this edition have been thoroughly revised and brought down to date.

Chapter II is entirely re-written, and is the work of Professor Todd of University College, Nottingham, the author of *The World's Cotton Crops*, upon which book certain parts of the new Chapter II, by the kind permission of the publishers (Messrs. A. & C. Black), are based.

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COTTON

CHAPTER I

FOUNDATION OF THE ENGLISH COTTON TRADE

THE importance of the Cotton Trade of the United Kingdom is seen in the amount of capital invested in it, the number of people employed in the sheds, factories, and works connected with the production and finishing of cloth step by step from the raw material; the thousands engaged in the distribution of the finished goods in all the markets of the world, and the variety of useful and artistic productions which come from the looms. The arts of Spinning and Weaving are among the oldest in the world. Long before the days of European history, people were vestured in woven cloths. Four thousand years before Christ, linen cloths were in common use in Egypt. Joseph arrayed himself in vestures of fine linen. When the Tabernacle was constructed in the wilderness, two centuries later, by Moses, "The women that were wise-hearted did spin with their hands, and brought that which they had spun, both of blue and of purple, and of scarlet, and of fine linen." Almost four centuries before the Christian Era, we are told that the ordinary wear of the Indians was cotton cloths. Strabo speaks of their flowered cottons or chintzes, and of the lustre and vivid quality of the dyes with which they figured their cloths. All over the East cloth fabrication was among the oldest

of all arts, and in America it is said that the arts of Spinning and Weaving were carried on by the earliest settlers, who found the cotton and indigo plants indigenous. The first record of cotton cloths among the argosies of the East is in *The Circumnavigation of the Erythræan Sea,* in which Arrian, an Egyptian Greek, refers to the Arab traders bringing Indian cottons to Aduli, a port on the Red Sea. Ports beyond the Red Sea had an established trade in calicoes, muslins, and other cottons, both plain and bearing floral ornamentation. It does seem remarkable, as Mr. Baines points out, that a branch of industry so apt to propagate itself should have lingered thirteen hundred years on the coast of the Mediterranean before it crossed that sea to Greece or Italy, for the costly silks of China had long before been quite eagerly sought by the ladies of Rome and Constantinople. From the East the textile arts gradually spread to Europe. In Greece, in the tenth century, silks, woollens, and linens were made, and silks were made on a large scale in Southern Italy in the twelfth, thirteenth, and fourteenth centuries. There were big woollen manufactories at the same period in Flanders, Tuscany, etc., but it was left to Mohammedan Spain to manufacture cloths from cotton as early as the tenth century, as well as to copy the artistic fabrications of the seats of Mohammedan luxury in the East. Venice exported a variety of cottons in 1560, and Milan sent out fustians and dimities of many sorts. The first record of cotton in English trade is contained in a work written towards the close of the fifteenth century by Hakluyt, who says that the ships of Genoa brought from England, among other commodities, cotton. In 1601 it is recorded that cotton was brought to England by the Antwerpians from Sicily, the Levant, and Lisbon. When

the refugees from the Low Countries in the second half of the sixteenth century, fleeing from persecution, settled in England, they are said to have pursued the manufacturing arts they had practised at home. There is however, no positive proof that the Flemish weavers, who settled in the neighbourhood of Manchester, did actually begin our English cotton manufacture. It is practically certain that many of the woven goods called "cottons" in 1552 were really woollen stuffs. As a matter of fact, for over 100 years after Roberts wrote his book on Traffic in 1641, India kept far in front of Europe in cotton manufactured goods, the Eastern trading companies gaining great wealth by the monopoly. In 1775 a patriotic association was formed at Edinburgh to discourage ladies from wearing the cotton robes of India in preference to the calicoes and lawns of Glasgow and Paisley.

By the year 1727 the cotton industry had so far developed as to enable Defoe, writing on Manchester, to say "the grand manufacture which has so much raised this town is that of cotton in all its varieties." In less than fifty years afterwards there were in and about Manchester over 30,000 people engaged in the cotton industry, and the woollen and linen industries were also pursued on an extensive scale, not only here but in other parts of Lancashire. There then was laid the foundation of that industry which has built up the great wealth and industrial pre-eminence of Lancashire. In Dr. Aikin's *Forty Miles Round Manchester*, published in 1795, he says, speaking of the recently introduced cotton industry, "that in the middle of the previous century the Manchester traders went regularly to buy fustians (a coarse cloth) of the weaver, each weaver then producing yarn or cotton as he could." Then he goes on to say that three-quarters of a century afterwards

"the Manchester merchants began to give out warps and raw cotton to the weavers, receiving them back in cloth, and paying for the carding, roving, spinning, and weaving." Next there arose "second-rate merchants, called fustian-masters, who gave out a warp and raw cotton to the weaver, and received them back in cloth, paying the weaver for the weaving and spinning, and these attended the weekly market at Manchester, and the middleman sold his pieces in the grey to the merchant, who afterwards dyed and finished it." The system was primitive, but it gradually spread over the hills, dales, and plains of Lancashire, and in other places. Very many of the farmhouses and cottages had their weaving shops, and the cellars of many labouring people in the towns and villages contained hand-looms. The cotton wool was, at the outset of the system, picked by the young children, and it was then carded and spun on the jennies by the elder girls or the good wife, the yarn being woven by the father or the sons. The women of the district were sometimes engaged by the hand-loom weavers, for one efficient industrious weaver could keep three women busy turning weft off the spinning wheels. It was often difficult to get weft, and the weaver was frequently unable to deliver his cloths to the manufacturers within the time he had contracted.

Postlethwaite, in his *Dictionary of Trade and Commerce*, in 1766, estimated that at Manchester, Bolton, and the neighbourhood they made over £600,000 worth of cotton goods annually. Fustians, cottons, tapes, etc., were sent on pack-horses to London, Liverpool, and Bristol for exportation. Manchester men travelled to different parts of the Kingdom to sell cloths to the tradesmen for home consumption. Baines tells us that "up to the year 1760 the machines used in the cotton manufacture in England were nearly as simple as those of India,

though the loom was more strongly and perfectly constructed and cards for counting the cotton had been adopted from the woollen manufacture." It was clear that means would have to be taken to multiply the yarn supply, or the expanding trade was in danger of being lost. The genius of inventors was first spent in the development of the domestic spinning wheel. In 1764 James Hargreaves, of Stanhill, near Blackburn, invented his spinning jenny, which was driven by a fly-wheel, and held a number of spindles slightly inclined from the perpendicular, a movable frame receding from the spindles during the extension of the threads and approaching them in its winding on. The alarm of neighbours lest it should destroy hand labour led them to break into the house and destroy the jenny. He left the district and went to Nottingham in 1768, where a joiner named Thomas James entered into partnership with him to erect a spinning mill on the jenny plan. Before patenting the jenny he found his machine had been extensively pirated in Lancashire. He died in 1778. Crompton, the inventor of the mule, learned to spin on one of these jennies in 1769. It was in that year that Arkwright, the Preston barber, secured his patent for a system of spinning by rollers, not a new idea, it is true, for a patent for a system of this sort had been taken out in 1738 by Lewis Paul, but the imperfection in mechanism prevented its general adoption. Arkwright's mechanism was much more perfect, and he and his partners began a little factory at Nottingham. Arkwright's system was widely adopted and used for spinning warp and hosiery yarns of a hard and compact fabric, of any grist up to seventy or even eighty hanks in the pound. Hargreaves's system spun soft weft yarn of rather inferior numbers, and these two independent systems for many years produced the cotton yarn of the country. The

jenny gave way to the wonderfully clever invention of Samuel Crompton, of Bolton—the spinning mule. Ure says: " In the place of Arkwright's bobbins and flyers Mr. Crompton used the spindle carriage of Hargreaves's jenny to receive, attenuate, twist and wind on the threads, after their emergence from the drawing rollers." The adoption of this mule, as improved by Henry Stones, a clever mechanic residing near Bolton, was followed by developments immensely increasing the volume of production and the fineness of the yarn. About this time there was invented the billy, a union of jenny and mule, by a Stockport man. The widely adopted mule was from time to time improved by various devices. For some time roving was a distinct business in the hands of those using Arkwright's carding and roving machines. They disposed of the rove to the hand mule spinners. These inventors gave a great impetus to the factory system.

In 1771 Arkwright built a mill at Cromford, and speedily the expansion of spinning began on his principle, in various parts of Lancashire especially. Inventions to expedite cloth production began at an earlier date. In 1738 John Kay, of Bolton, invented the fly shuttle, a picking stick driving the shuttle instead of the old method of hand throwing. In 1760 Robert Kay, the son of John, invented the drop box to accommodate shuttles holding threads of various colours. In 1760 the swivel loom, adopted from the Dutch, and weaving a number of narrow pieces (tapes, etc.) at the same time was introduced. Then came the invention of the harness-loom for figured goods, and this was subsequently superseded by the Jacquard loom, with its elaborate system of perforated cards. The commencement of the factory system began with master weavers who employed children, apprentices and journeymen. Some employers

had looms on their premises and engaged weavers. From the ranks of these rugged, strong men, with the northern grit and grand spirit of self-reliance, there emerged in time some of the richest cotton lords of Lancashire and the far North; for Scotland, the land of education, progress, and lusty men, had taken up the cotton manufacture in several places at an early period. For a time the domestic system prevailed in manufacturing.

The inventions to increase the output of yarn succeeded so well that loom improvements became an absolute necessity. In 1787 the Rev. Edmund Cartwright invented the power-loom, which produced more uniform cloth with far greater rapidity, but it was only adopted slowly. Glasgow made the first use of this loom at the end of the eighteenth century. In 1820 only about 14,000 power-looms were in use in the United Kingdom, whilst the number of hand-looms approximated a quarter of a million. Subsequent to 1836 the power-loom became rapidly adopted, and this was largely due to the economical advantage of the invention of Radcliffe and others to enable the warp to be dressed before it went to the loom, instead of the loom having to be stopped to dress the warp. The loom, too, was improved by the cloth being taken up mechanically instead of having to be pulled forward by the weaver. Other improvements, which will be dealt with later, perfected the loom to that high degree of automatic mechanism which we see in the power-looms of to-day.

Following the erection in 1770 at Nottingham of Arkwright & Partners' horse-driven mill, there was in 1771, built at Cromford, in Derbyshire, Arkwright's larger mill, driven by water-wheel (which gave to Arkwright's invention the common title " water-frame "). Between 1776 and 1778 half a dozen mills were built in

Oldham, three worked by horses and three by water-power. Then the mills spread over Lancashire, being often placed in the valleys to get the advantage of the water-power from the rivers and their tributaries, which transformed peaceful vales into busy and well-to-do communities. Then came the invention of Watt's steam engine, applied first in 1785 to a cotton mill at Pepplewick. It was adopted in Bolton and Glasgow, and next in Oldham. Water-power was gradually substituted by the steam engine, and there was seen more and more the concentration of factories and weaving sheds in towns and valleys. Hand-loom weaving gradually declined, the putting-out shops and the weaving rooms were closed one by one, and the stalwart, self-reliant weavers came into the towns and villages, and lived the busy life of the operative, whilst the farmers' sole business became attention to the agricultural arts and stock breeding, whereas formerly it was divided between weaving cloth and cultivating the land. It was a peaceful revolution, fruitful in blessings and prosperity. Our trade expanded in all directions, and the Exchange at Manchester became the great emporium of the world for the distribution of cotton goods, both fancy and plain. One cannot attempt to encompass in an epitome all the inventions in the mechanical arts bearing upon cotton trade evolution and expansion. We in this kingdom got the start of the world, and our home market, our colonies and possessions beyond the seas became our bountiful patrons. Production multiplied apace. Lancashire especially grew abundantly in riches and power under the textile system. Swift rail and sea transport all came in as auxiliaries of trade development, and the huge mercantile system brought out some of the ablest, most enterprising, and most honourable men of the nation. The trade has had its periods of

prosperity and depression, of strikes and lock-outs, which can only be thus generalised. It has had to face a yearly growing competition from Continental nations, and from both the Northern and Southern States of America, and even the Far East in lesser measure. The wide adoption in England of the co-operative principle has largely transformed mill ownership and stimulated industrial development. Legislation has improved the lot of the worker from time to time. Consolidation, centralisation, and specialisation are more and more yielding economical and commercial advantages. There has been a gradual co-ordination of forces. The operatives began their unions in the early days of the factory system. Then Masters' Associations were formed. Now the workpeople in the spinning, cardroom and weaving and other branches, have their separate organisations, all very powerful, and for certain objects federated. The employers have had to lengthen their cords and strengthen their stakes. They have great district Associations and a Federation, the most powerful in the world, of the Master Cotton Spinners' Associations. The operatives spread their organised work to international proportions, bringing into line for common objects Continental operatives of all nations with themselves. The employers have followed their example, and have founded one of the greatest combinations the world has known—the International Federation of Master Cotton Spinners' and Manufacturers' Associations. These organisations are referred to in the final chapter.

The following facts illustrate the enormous magnitude of the cotton industry to-day. The total estimated number of raw cotton spinning spindles in work prior to the outbreak of the European War was as shown on next page.

	Spindles.
Great Britain	55,971,501
Germany	11,404,944
France	7,400,000
Russia	9,111,835
Austria	4,941,320
Italy	4,600,000
Spain	2,200,000
Japan	2,414,544
Switzerland	1,383,572
Belgium	1,518,134
Portugal	482,000
Holland	499,994
Sweden	550,000
Norway	55,772
Denmark	93,488
U.S. America	31,519,766
India	6,397,142
Canada	860,000
Mexico, Brazil, and other Countries	3,300,000
	144,704,012

There are quite 6,000,000 doubling and waste cotton spindles, besides the above raw cotton using spindles.

The total estimated number of looms in the United Kingdom and Ireland is about 806,000. It is very difficult to estimate the number of looms abroad, on account of the large number of hand-looms still in use in some parts of the world; but, roughly speaking, there must be 2,000,000 power-looms in the world, besides the 800,000 of Great Britain.

It is stated on the authority of Sir Charles W. Macara, Bart., a former Chairman of the Committee of the International Federation of Master Cotton Spinners' and Manufacturers' Association, that the cotton industry

manipulates raw material in one year of the value of over £200,000,000, and that it distributes throughout the markets of the world manufactured goods of the value of £450,000,000, or eleven thousand two hundred and fifty million francs. This statement was made in 1908, since when prices are almost double that value.

Up to the early seventies, England occupied a preponderating position in the cotton industry; this, however, has entirely changed, as is seen from the preceding table.

Sir Charles W. Macara, speaking in Zurich in 1904, on the occasion of the foundation of the International Cotton Federation, gave the following interesting particulars—

> "There is little doubt that the expansion of cotton machinery throughout the world has been so great that for four successive years the supply of the raw material has been insufficient to run the cotton spindles of the world.
>
> "There is no industry in Great Britain, excepting agriculture, which affords so much employment, directly and indirectly, for the masses of the people as the manipulation of cotton, or which is of more importance to the whole mercantile and industrial system of England.
>
> "Estimating the raw cotton at an average price of 5d.[1] per pound, £40,000,000 worth is imported annually, an average of about £5,000,000 worth is re-exported in the raw state, leaving the balance of £35,000,000 worth of cotton to run the spindles and looms.
>
> "This cotton, after being converted into yarn or cloth, and after undergoing one or more of the further

[1] Prices to-day are more than double this figure.

processes of finishing, bleaching, dyeing, printing, making up into pieces, or being converted into ready-made garments, is finally packed and disposed of by the distributors at home and exporters at an estimated value, on the same basis, of over £90,000,000, leaving, as will be seen, a balance of over £55,000,000 to pay imperial and local taxation, profit on capital invested, depreciation on buildings and machinery, coal, mill stores, etc., and wages, this last item representing by far the largest proportion of the £55,000,000. The raw material is largely brought to England by British ships. When landed at the ports it forms an important part of the mercantile transactions of these ports, and the warehousing and handling of it employ a large amount of labour. The carrying of this raw material to the cotton spinning mills forms a substantial source of revenue to some of the most important railway companies and to the Manchester Ship Canal. In the further carrying of the yarn to mills engaged in the weaving branch of the cotton industry another large source of revenue accrues to the railway companies and other carriers.

"Owing to the great variety of cotton goods produced in England, the majority of manufacturers have to supply their requirements from numerous spinners, there being comparatively few mills that combine both processes of spinning and weaving.

"Again, the grey cloth has to be carried to the warehouses of the distributors or to the works of the finishers, dyers, printers, bleachers, and ready-made clothing manufacturers; these further processes involving another rate for the railway companies before the goods reach the warehouses of the distributors, who finally are responsible for their distribution to the home and foreign markets; this again

bringing in further revenue to the railway companies, shipowners, and other carriers. Like the handling of the raw material, the distribution of the manufactured products of the spindles and looms forms another important part of the commercial transactions of the nation, more especially as regards Lancashire.

"From the standpoint of employment, a study of the position is even more impressive. As already stated, the handling and warehousing of the raw material at the ports find employment for a large number of people. The repeated carrying in connection with the various processes of manufacture gives employment to a much larger section of the population.

"The cotton operatives engaged in spinning and weaving number, in round figures, 500,000. The number employed in the subsidiary industries and employments connected with cotton, already enumerated, is more difficult to estimate, but it will amount to another 500,000. Allowing two dependents only to each worker (there being a large number of young people employed) a population of no less than 3,000,000 is represented.

"There are further the dependent industries, such as the great machine-making and engineering establishments, which are largely employed with repairs, renewals, and extensions in the British cotton and subsidiary industries, also a portion of the mining and chemical industries; all of which represent a further section of the population. The provision trade is obviously mainly dependent on the masses of the people. In any dislocation of the cotton industry its serious effects on employment generally would be widespread. But it would not end here; the retail, mercantile, banking, professional, and

leisured classes would all suffer severely; and so would the landowners, property owners, and the agricultural classes, who find their largest markets in the great mercantile and industrial centres of the North of England."

CHAPTER II

COTTON GROWING

THE word cotton may be traced to the language of Arabia, a country where the plant is indigenous. Cotton was doubtless used for clothing in the very early days of human history. It was introduced into Western Europe at the era of the Mohammedan conquest, and, as a matter of fact, it was in Mohammedan Spain that the cotton manufacture first began in Europe.

Cotton was well known and in common use in India long before the Christian era, for in a book written about 800 B.C. the plant is referred to frequently, and in such a way as to show that it was quite familiar. Nearchus, the admiral of Alexander the Great, who took part of his army along the shores of the Arabian and Persian Gulf about 327 B.C., says: "There are in India trees bearing as it were branches of wool. The natives made linen garments of it, wearing a shirt which reached to the middle of the leg, a sheet folded about the shoulders, and a turban rolled round the head, and the linen made by them from this substance was fine and whiter than any other." Our word "calico" was originally given to this familiar material because it came from the Indian port of Calicut. From India cotton plants were probably sent to China and other neighbouring countries.

Later explorers found cotton in other regions. For example, in 1492, Columbus noted that it grew abundantly in the West Indies and on the neighbouring coasts of America, and that the natives had considerable skill in making it up into cloth. In Mexico, Peru,

and Brazil, cotton was well known, and in Mexico it was the chief article of clothing. In parts of tropical Africa cotton grows wild, and is used by the natives to make cloths.

Cotton belongs to the order of the *Malvaceae* or mallows, its generic name being *Gossypium*. It is, therefore, related to the English hollyhock, which it remotely resembles.

Experts in systematic botany differ greatly as to the number of separate species which can be distinguished, but the following are generally recognised—

A. Group of Old World or " Asiatic " Cottons

Gossypium herbaceum.—This includes most of the Indian and Levant cottons, and the native types of Russian Turkestan and Persia.

Gossypium arboreum or tree cotton. Although tree cottons are found in other sections also, this name is usually restricted to a type resembling the Asiatic, and includes the sacred tree cotton of India.

B. Two Groups of " Non-Asiatic " Cottons

1. The Upland Group.—*Gossypium hirsutum* is so called from the hairy character of the plant, in stem, leaves, and seed. The American Upland is the chief representative of the Group, to which the Indian Cambodia cotton also belongs. The group is possibly also Asiatic in origin, though its most important cultivation is now in the New World.

2. The Peruvian Group.—*Gossypium barbadense, maritimum,* and *peruvianum*. This group includes the Sea Islands, Egyptian, Peruvian, Caravonica, and other cottons. The exact origin of these forms, which include the best kinds of lint on the market, is uncertain. They might also be roughly distinguished as the " vine-leaf " cottons.

In appearance and growing characteristics, the cotton plant varies greatly in different countries, but it may be described as generally a bushy plant, growing about 3 to 6 ft. high, with more or less widespreading branches, especially on the lower portion of the stem, and tapering to a pointed top. When closely planted, the development of the branching is reduced, and the plant grows more like a raspberry bush than a gooseberry. The root system also differs greatly according to the nature of the soil and the water supply. In Egypt, for example, the main tap-root has been shown to descend over 6 ft. into the ground in search of water, and it is probable that it would do the same elsewhere if conditions allowed. While, therefore, cotton does grow well on shallow soils (as in Barbados), it does much better in deeper soils.

The leaves are large, and more or less deeply divided into three or five lobes, the form differing greatly in the different species and varieties. Thus, Sea Island has very deeply cut lobes, while American Upland represents the opposite extreme (more like an ivy-leaf, but covered with hair, which gives it a dull appearance. The Indian leaf is smaller, with lobes characteristically rounded in appearance.

The flower also differs considerably in colour from one species to another. It resembles generally the flower of the hollyhock in shape, but is more tubular, and is surrounded by three large bracts, or outside leaves. The flower of the Sea Island and most Egyptian types is lemon or golden-yellow, with crimson spots at the base of the five petals inside, and a golden brush of stamens ; but that of the ordinary American Upland is creamy, usually without any markings, and has buff-coloured stamens.

The Indian flower is also yellow, but smaller than the

Egyptian, and the spots are larger and darker. The flower of the sacred cotton tree, and of some other varieties in India, is red. In fading, if the atmosphere is humid, the yellow flower turns pink, and finally almost red, before it withers. It only remains open for one day.

The boll, or fruit, before maturity, is of varying shades of green, and differs very greatly in size—from $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. in diameter—and in shape in the different varieties. Thus, the Sea Island and Egyptian bolls, especially the former, are narrow and pointed; while the American Upland is much rounder and appears much shorter. Some of the new varieties of medium staple American cotton have very large but pointed bolls.

The boll is divided into from three to five *loculi*, or compartments, each containing a "lock" of seven to nine seeds, to which the lint—the actual cotton itself—is attached. Here, again, is a marked difference, according to the species and variety. The Sea Island and Egyptian seeds are black or brown, and the lint comes easily and completely away from the seed in the process of "ginning," or separating the lint from the seed, except for a small tuft of short fuzz at the point in certain varieties. They are, therefore, known as "black" or "clean" seeds. In the American Upland and Indian varieties, on the other hand, there are two kinds of hair: one—the actual cotton or "lint"—being of about an inch in length, and coming away easily from the seed in the "gin"; the other is a short fuzz, which adheres very closely to the seed, and is only partially removed, even by the subsequent process of "delinting." What is removed by this process is known as "linters," and forms an appreciable, though until the war not valuable, addition to the American crop. Its most important use now is as the raw

material of gun-cotton. These seeds are known as "white" or "fuzzy."

The length, strength, fineness, and character of the lint are, from the spinner's point of view, the characteristic distinguishing marks of the different varieties. Sea Island staple, for example, often exceeds 2 in. in length; Indian, on the other hand, may be less than ½ in.; while the diameter of the fibre varies from 0.0007 to 0.0001 of an inch. The appearance of the lint in the open boll also varies immensely, from one type of Indian, in which, when ripe, the contents of the boll hang right out to the length of 2 or 3 in., like a bunch of grapes, to that of the Sea Island, in which the lint clings closely to the lock in a peculiar curled condition, like raw silk.

The seed generally forms about two-thirds of the gross weight of the seed cotton, and the lint one-third; but this proportion, or "ginning out-turn" is much lower in the case of many varieties, and higher in others —varying from 25 to 50 per cent.

The climate most suitable to cotton growing may be described as subtropical. The period of growth of the plant from sowing to picking is about five to nine months, but in many cases the picking season is very long drawn out. Cotton requires an ample water supply, which may be derived from natural rainfall or from irrigation. It is important to notice how rapidly the growth of cotton under irrigation has developed in modern times. Cotton was certainly at first a rain crop (*i.e.*, a "monsoon" crop) in India; but the quantity of cotton grown under irrigation in every part of the world is now very large. Indeed, it appears that the best growing conditions can only be secured by irrigation. In America, for example, the crop suffers very seriously in certain seasons, owing to damage by

untimely rain, which stains or "tinges" the ripe cotton and materially lowers its value; while, on the other hand, where irrigation is not possible, the crop is liable to serious damage by drought during the growing period.

Where the growing season is likely to be prematurely closed by severe frost, the amount of the crop is liable to severe fluctuations. In America, for instance, the date of the first killing frost in autumn is often the determining factor in the final yield of the crop. Frost, on the other hand, is the worst enemy of certain insect pests, which prey upon the cotton, such as the boll weevil in America. Again, the extermination or reduction of such pests is often assisted by summer droughts: for most of them seem to flourish best under moist, shady, and relatively cool conditions.

The cotton crop requires a considerable amount of intensive cultivation at certain periods. Thus, after sowing, it requires to be "chopped" or thinned out, and the ground carefully "cultivated" (hoed) to keep it clear of weeds, and also to prevent unnecessary evaporation of the moisture of the soil. There is usually a period before final harvesting, when the crop is "made," or "laid by" as it is called in America, and requires little attention until picking time arrives. Picking itself requires an immense amount of labour, which, indeed, is in many cases the limiting factor in the extension of the crop. Thus, on the whole, cotton is essentially a cheap-labour crop, and the best results are obtained when hand labour can be used throughout, as in Egypt.

The methods of picking, ginning, baling, handling, and selling the crop vary greatly in different countries. The two main methods of ginning are by the roller gin, which is used in Egypt and the Sea Island districts,

and generally wherever long staple cotton is grown. By a strange paradox, it is also very largely used in India even for the shortest stapled cotton. The great bulk of the world's cotton, however, is ginned by the American saw-gin. The character of these two types of machine is sufficiently indicated by their names. In certain parts of Russia, China, and India a peculiar type of cotton is grown which, owing to the in-growing habit of the lint, must be plucked bodily from the plant and the lint extracted at leisure afterwards.

From the side of supply as well as demand, the world's cotton market has increased in complexity and specialisation during the last twenty years as greatly as it has in bulk and extent. The Weekly Circular of the Liverpool Cotton Association before the war quoted the prices of no less than forty-six different varieties of cotton, of which 4 were American, 5 Peruvian, 6 Brazilian, 2 West Indian, 6 Egyptian, 2 African, 19 Indian, and 2 miscellaneous (Chinese and Levant).

All of these have their own peculiar qualities and special uses. As will be seen from the table on page 24, their values varied in July, 1914, from, say, 4d. per lb. up to 40d. per lb., with the basis price of American Middling about 7d. Most of them are specially adapted for and are mainly employed in particular trades. All of them, however, are more or less interdependent, both as to supply and demand. There is a good deal of overlapping in the supply of different varieties—areas which may, and do, grow one variety or another at different times, according to varying conditions or the movement of prices. Thus, there are parts of the Carolinas and Georgia which could grow either Sea Island or short staple Upland. On the other hand, there are increasing possibilities of substitution of one variety for another in spinning, such as the substitution

of American long staple for Egyptian cotton, or of the better grades of Egyptian for Sea Island.

For the sake of clearness, some system of classification of the different varieties of cotton into broad grades must be attempted, though it must be understood that no such classification exists in practice in the trade, and that the limits of the different classes are by no means clear or exact. The writer has attempted to frame such a classification, taking the different classes of cotton according to their quality or spinning capabilities, as follows—

1. The best cotton of all is the true Sea Island, grown on the Islands (hence the name) off Charleston, South Carolina, and also in the West Indies. The total quantity of these crops is very small, but their value is very high on account of their marvellous spinning qualities. The best Sea Island can be spun as high as 300's or even more, which means that 150 miles of the yarn spun from such cotton weighs only 1 lb. The use of these fine yarns is, of course, confined to the very highest grades of fabrics and the finest sewing cottons. They are largely employed in the Nottingham lace trade.

2. Next to these come certain grades of Sea Island, grown in Georgia and Florida, which are of excellent quality, though not so superfine as the real "Islands." In this class, too, must now be included the best Egyptian grades, such as Abbassi, Sakel, and Jannovitch, which are second only to the finest Sea Islands in quality and spinning capabilities. They are also extra strong, which has given them certain special uses of their own where strength and fineness are essential.

3. In the third grade may be placed the ordinary varieties of Egyptian cotton (*i.e.*, Nubari, Afifi or Brown Egyptian, and Ashmuni or Upper Egyptian). In competition with these during recent years have

been the best varieties of American long staple Upland cotton, which for many purposes have proved themselves almost as good as ordinary Brown Egyptian. Peruvian cotton comes very close to this class of cotton and some of the best of the new African cottons.

4. The great bulk of the world's cotton supply, however, consists of the ordinary American Upland crop, which amounts to about 60 per cent. of the whole world's crops. This has, of course, no rival in the matter of quantity, but there are various smaller crops which are round about the same quality (*e.g.*, Brazilian, West African, Russian, Asia Minor, and, in recent years, some of the improved varieties of Indian cotton). Some of the Chinese crop may also be included in this grade.

5. The greater part of the Indian crop, however, is in a grade by itself, of a very short staple and inferior quality. It is little used in Lancashire, but is largely employed in the local mills of India, in Japan, and also in most of the continental spinning countries. Similar to the Indian crop in quality are certain of the native varieties of Russian cotton. Finally, the great unknown of the cotton trade—the Chinese crop—is probably, on the whole, of Indian quality.

The available statistics with regard to the average supply of these different grades of cotton are summarised in the table on page 24 which also indicates in each case how much of the supply is produced in the British Empire.

The following brief notes on the principal cotton-producing countries are arranged in geographical order—

America: The United States

As will be seen from the table on page 25, the American crop still forms more than half of the

THE WORLD'S COTTON SUPPLY, AND THE BRITISH EMPIRE'S SHARE IN IT

Grade.	Quality.	Staple.	Where Grown.	Pre-war Prices, 10/7/14.	World's Crops.	Bale Weight.	Empire's Share.	Per cent.
		Inches.		Price per lb.	Bales.			
I.	*Best Sea Island*	2 and over	Islands, South Carolina	12½–18[1]	10,000	400 lbs.		
			West Indies	13 –18½[1]	5,000	400 ,,		
					15,000		5,000	33
II.	*Second Grade Sea Islands*	1½–1¾	Florida and Georgia	11½–12½	70,000	400 ,,		
		,,	West Indies	,,	2,000	400 ,,		
	Best Egyptian (Sakel, etc.)	,,	Egypt	10 –11½	430,000	740 ,,		
					502,000		432,000	86
III.	*Egyptian*	1¼–1½	Egypt	8½–10¾	1,000,000	740 ,,		
			Sudan	,,	25,000	400 ,,		
	Staple American	,,	Mississippi Delta, etc.	up to 10½	200,000	500 ,,		
		1⅛–1¼	Nyasaland, Uganda, and East and South Africa	6½–10	50,000	400 ,,		
		1 –1½	Peruvian	7 –10	125,000	250 ,,		
					1,400, 000		1,075,000	77
IV.	*American*	1 –1⅛	U.S.A.	Middling 7–33	15,000,000	510 gross		
			Mexico		150,000			
		¾–1¼	Brazil	6–9	300,000	250 ,,		
		⅞–1⅛	Russia	(5–7½)	1,000,0000	250–500		
		1 –1⅛	West Africa	6¾–7½	15,000	400 ,,		
		¾–1⅛	Levant	(5–7½)	100,000	440 ,,		
		1	India	up to 7d.	250,000	400 ,,		
		1	China and Corea		250,000	500 ,,		
					17,065,000		265,000	1·6
V.	*Indian*	¾ up.	India	3¾ upwards	5,000,000	400 ,,		
		,,	Russia		400,000	250–500		
		,,	China	(4–6¼)	1,800,000	500 ,,		
					7,200,000		5,000,000	69
					26,182,000		6,777,000	26

[1] Crop lots up to 40d

On page 25 will be found a table giving the actual statistics of the world's chief crops since 1902, while a map of the World showing the geographical distribution of cotton will be found at the end of the book.

THE WORLD'S COTTON CROPS, 1902-1916

IN BALES OF APPROXIMATELY 500 LBS—000'S OMITTED.

Season.	America.	India.[1]	Egypt.	Russia.	China.	Others.	Total.
1902–03.	10,758	3,367	1,168	342	1,200	801	17,636
1903–04.	10,124	3,161	1,302	477	1,200	751	17,015
1904–05.	13,557	3,791	1,263	536	756	803	20,706
1905–06.	11,320	3,416	1,192	604	788	936	18,256
1906–07.	13,551	4,934	1,390	759	806	1,027	22,467
1907–08.	11,582	3,122	1,447	664	875	950	18,640
1908–09.	13,829	3,692	1,150	698	**1,250**	969	**21,588**
1909–10.	10,651	4,718	1,000	686	**1,750**	950	19,755
1910–11.	12,132	3,853	1,515	895	**1,800**	967	**21,162**
1911–12.	16,043	3,288	1,485	875	**1,800**	1,058	**24,549**
1912–13.	14,129	4,395	1,507	911	**1,800**	1,171	**23,913**
1913–14.	14,610	5,201	1,537	1,015	**2,000**	1,340	**25,703**
1914–15.	15,067	5,209	1,298	1,247	**2,000**	**1,300**	**26,121**
1915–16.	12,953	3,819	961	1,465	**1,750**	**1,100**	**22,048**
1916–17.	**12,500**	**4,500**	**1,200**	1,500	**2,000**	**1,200**	**22,900**

The figures in **heavy type** are the Author's estimates.

[1] These are the Government estimates, which are notoriously understated. On the other hand, Indian bales are only 400 lb. weight. Taking the Government figures as 500-lb. bales, as is done here, probably offsets the under-estimation fairly well on the whole, though roughly. The following table from *The Economist* of 23rd September, 1916, seems to justify this approximation.

Season.	Government Estimate.	Approximate Actual Crop.		
	400-lb. Bales.	400-lb. Bales.	500-lb. Bales.	
1908-09	3,691	4,744	3,795	Based on Exports, Indian Mill Statistics, and estimated domestic consumption.
1909-10	4,718	5,341	4,273	
1910-11	3,853	4,974	3,979	
1911-12	3,288	4,643	3,714	
1912-13	4,610	5,019	4,015	
1913-14	5,065	6,684	5,347	
1914-15	5,209	5,279	4,223	
1915-16	3,819	5,559	4,447	
Average	4,282		4,224	

world's cotton supplies. The area of the American Cotton Belt, as it is called, is enormous—about 700,000 square miles, or nearly six times the total area of the United Kingdom. It extends into 18 out of the 49 states of the Union, but only 10 produce more than 100,000 bales per annum. Of the total area of the Belt, less than one-tenth part is under cotton, the record figures in 1913 being 37,458,000 acres.

The Belt may be divided into three main areas: the Eastern or Atlantic States; the Gulf States, with Texas (which is almost large enough to be regarded as a separate area); and the Mississippi Valley. In addition to these main divisions, there are two districts of which the total area under cotton is still comparatively small, but which promise great developments in the future, namely, the irrigated districts of the Salt River Valley in Arizona and the Imperial Valley in California.

Throughout this enormous area the climatic conditions vary considerably. The whole crop, however, with the exception of the small irrigated districts above

mentioned, is a rain crop, and the chief variation in the climate of different districts is in the amount of the rainfall. On the Atlantic seaboard it is very heavy. In the Central States the rainfall is less, but the Mississippi and its various tributaries provide ample moisture, and frequently cause disastrous floods. In Texas again, certain parts of the State are liable to occasional severe drought, which may seriously reduce the yield of a year's crop. A considerable rainfall is, therefore, required in winter to put a good season into the ground as it is called (*i.e.*, to provide a good supply of moisture against the summer scarcity). The spring rains which are necessary for planting in all States may, if excessive, have the effect of hardening the surface of the ground so that the seedlings cannot break through, and thus necessitate re-sowing. Again, in summer, the crop is at the mercy of the weather, too much precipitation being as harmful, and about as likely in certain districts, as the opposite extreme of drought in others. Fine weather in autumn is essential to the proper maturing of the crop, and during the picking season it is still liable to damage by rain, which throws up mud into the low-growing open bolls, thus producing stained cotton. As, owing to the lack of labour, the picking season is sometimes very long drawn out, much of the crop may suffer such "winter damage" through being left on the plants half through the winter. Finally, the ultimate out-turn of the crop depends on the date of the first killing frost, which stops growth and kills the "top crop" or late maturing bolls on the upper branches of the plant. On the other hand, winter frosts and summer droughts serve a useful purpose by keeping down the numbers of the boll weevil, which does so much damage in nearly all parts of the Belt now, except the most northern.

The distribution of the different varieties throughout the Belt may be indicated as follows: The best Sea Island cotton, grown only on a few small islands lying off the coast of South Carolina opposite Charleston, has already been referred to. Next to this come Florida and Georgia Sea Island cotton, grown from Island seed in certain portions of South Carolina and Georgia, near, but not on, the coast, and in Florida. Long staple Upland cotton, sometimes called Benders, the best of which is little below the second-grade Sea Islands, is grown in the so-called Mississippi Delta (which is really the delta of the Yazoo River and the Mississippi), about 250 miles from the mouth of the latter. The great bulk of the crop, however, is the ordinary Upland cotton, which is spread over the whole Belt.

There are many different grades or varieties included in the Uplands class, from the real Uplands (so called originally from the fact that they were grown in the Uplands of the Atlantic States) to Orleans and Texas, which are superior grades. Uplands are also sometimes called Bowed Georgias, from the peculiar form of gin, like a bow string, upon which they were formerly ginned, and which still survives in the East. Finally, the new Western districts of Arizona and California produce very fine, long-stapled American and some Egyptian cotton.

The methods of growing and handling the crop vary considerably in different districts, but the following description may be taken as applying generally to the ordinary Upland crop throughout the Belt. The dates of sowing and picking are naturally the most variable factors, but, generally speaking, sowing begins as soon as possible after the danger of frost is safely past. This means as early as the end of February or beginning

of March in South Texas, and as late as the third week in May in the high-lying parts of the Atlantic States. Preparation of the ground is done in spring rather than in the preceding autumn. Deep ploughing is very little practised owing to lack of labour ; and in many cases, ploughing so-called is confined to turning over the ridge of the previous year's crop into the adjoining furrow, so that the plants occupy alternate lines in successive years, for in many cases cotton is planted year after year in the same field. The distance between rows is supposed to correspond roughly with the expected height of the plant, say, 4 to 6 ft., but the former distance is probably more common than the latter. "Chopping" or thinning out begins about two to four weeks after sowing, when the plant is about 5 in. high, and a distance of 12 to 14 in. is left between the plants. Cultivation begins soon afterwards, and goes on at intervals of about three weeks until July or August. Its object is to remove weeds, especially grasses, for the cotton crop must be kept particularly free of weeds, and to keep the surface of the ground well broken so as to minimise evaporation. It is generally done by special machines called cultivators, which work along the rows between the plants, for which purpose the rows must be wide enough apart to allow a horse to pass between. Hoeing between plants is also found desirable. Cultivation is generally repeated about five times, if labour is available.

Flowering begins about two months after sowing, when the plants are, as a rule, about 15 in. high. The earliest bolls begin to form about three months after sowing, and take from one to two months to ripen. One of the characteristics of Upland cotton is the way in which the boll, when ripe, opens wide and allows the cotton to protrude freely, so that the whole contents

can be picked easily in one handful. The flowering and fruiting periods of the cotton plant are long drawn out, so that they overlap considerably, and flowers and ripe bolls are generally to be seen simultaneously on the same plant.

The date when picking begins varies from the middle of July in South Texas to the end of September in the latest districts, and goes on practically throughout the winter, owing to the lack of labour to pick it immediately it is ripe. There are generally at least three pickings about a month apart, but most planters pick whenever they can get labour and there is ripe cotton on the plants (which is practically all the time). Picking is everywhere performed by hand, none of the picking machines so far invented having yet been a real success.

The methods of ginning and baling the crop in America are, in some respects, very good and, in others, extremely unsatisfactory. The modern power gin plant, of which the use is spreading rapidly, especially in Texas, is very satisfactory, and produces an excellent flat bale of about 500 lb. gross, with a very light tare. But the peculiar method of sampling the bale in America results in the bale being so much cut to pieces before it is finally sold for export, that it has to be done up again, or "compressed" as it is called, which is also intended to reduce its bulk for shipping purposes. In the process of compressing, however, the bale, instead of being entirely re-covered with fresh bagging as it ought to be (and is in Egypt), is merely patched, with a few pieces of heavy bagging thrown over the holes, and then re-tied with a few extra bands. The result is that in the course of the rough handling which it subsequently receives, the covering becomes torn and open, and considerable

quantities of the contents escape or are damaged by dirt and damp. Repeated efforts have been made to remedy this very unsatisfactory state of affairs which annually leads to the loss of an enormous aggregate of cotton in small quantities, but hitherto with very little effect.

The history of the American crop as a commercial factor in the world's supply dates really from the invention of the saw gin by Eli Whitney in 1793. From that date the total amount of the crop and the proportion exported increased with remarkable rapidity, until about 1820 it practically dominated the English industry. The Civil War and the consequent blockade caused an absolute cotton famine in Lancashire, with the direst results to the industry; but all the efforts made then to develop other possible fields, especially in India, had no lasting effect.

Two things have helped to retard the natural development of the American crop in recent years. These are the scarcity of labour (and its consequent high cost) and the depredations of the boll weevil. Cotton is a crop which requires, at certain seasons, highly intensive cultivation, and labour must be plentiful and reasonably cheap to make its cultivation in the best way feasible. But labour is now both scarce and dear in most parts of the United States; in Texas, in 1913, day wages were as high as a dollar or a dollar and a half per day, while the pickers received from 70 cents to a dollar per 100 lb. of seed cotton picked. As the ginning out-turn is about one-third, this means that the actual cost merely of picking the cotton is not less than 2 cents per lb. of lint. The prices of everything the planter requires, such as mules, farm implements, fertilisers, and feeding-stuffs of all kinds, have also gone up to an extraordinary extent in recent years,

with the result that the cost of production of cotton is probably not less than 12 cents per lb. in Texas.

The advance of the boll weevil year by year has done much to make cotton growing less profitable than it ought to be. This famous pest first appeared in Mexico in 1862, crossed into Texas in 1892, and has

Photo by *Newton & Co.*

SEA ISLAND COTTON

since been spreading rapidly throughout the Belt, covering new ground almost every year. The last two years have seen a record advance, and it is now fairly into the Atlantic States, where its further progress, owing to the peculiarly favourable character of the climate and the vegetation, will almost certainly be more rapid than ever. Its worst damage will probably be in the Sea Island districts, for the conditions which

suit the boll weevil best are a moist, warm climate with little frost, and ample vegetation in which it can shelter during the winter. At the same time, it does its worst damage to late maturing cotton, such as Sea-Island, and there is, therefore, very little hope of saving the Sea Island crop when the boll weevil gets hold on the district. As it is, the Sea Island is a difficult and expensive crop to grow, and it will not take much to make the growers turn over completely to short staple cotton.

The West Indies

Should the American supply of Sea Island be lost through the advance of the boll weevil, the only alternative supply of the finest cotton will be in the West Indies. There, thanks largely to the assistance of the British Cotton-Growing Association, the islands—many of which were ten or fifteen years ago threatened with economic ruin through the failure of other crops, such as sugar—have been rescued and made prosperous again by the re-introduction of the cotton plant from the Sea Island districts. The conditions in the West Indies are in many ways similar to those of the Carolina Islands ; and while space will not allow of any detailed description of the various islands or their different conditions, the following summary of the resulting crop may be given : Of the total of, say, 7,500 bales of Sea Island quality, about 1,500 are equal to the best or Crop lots of Islands cotton, which before the war fetched as high as 40d. per lb. in Liverpool. They are grown chiefly in St. Vincent, St. Kitts, and Barbados. Of the remainder, about 4,000 bales are considered equal to Graded Island cotton, and the remaining 2,000 to Floridas and Georgias. There is also a quantity

of lower grade cotton, known as Marie Galante, a wild type of native cotton, believed to be related to the true Sea Island, but of inferior staple, which amounts to well over 1,000 bales. In Hayti there is a large crop amounting apparently to about 10,000 bales, of a still lower type, which, however, is not usually counted in the West Indian crop at all.

MEXICO

Mexico is typical of the Spanish and other colonies in Central and South America, countries of great possibilities for cotton growing, but very poor performance. There is no doubt that an enormous crop could be produced in Mexico, partly under irrigation, for which there is ample water supply if it were properly taken in hand ; but there is no prospect at all of this being done for some time to come, owing to the very unsettled state of the country both economically and politically.

BRAZIL

Cotton has been cultivated in Brazil probably from time immemorial, and was found growing there by the Portuguese in 1500. It was first introduced into England in 1781, and was our chief source of supply till 1800. At one time, great quantities were exported ; but during recent years many mills have been erected in the country, and probably the greater part of the crop is now consumed there. There is no doubt that the possibilities of the country for cotton growing are immense, but all the necessary conditions seem to be lacking, viz., energy, capital, and labour. The reported yields per acre are almost the highest in the world, and

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COTTON FIELDS—GATHERING RAW MATERIAL

run Egypt very close. The cotton area is large and is spread over a very large part of the country. The names of many of the provinces and some towns in the cotton growing districts are found in those of the types of cotton named in the Liverpool list, such as Pernambuco, Parahyba, Rio Grande do Norte, Maceio, Mossoro, and Ceara. In these different provinces the conditions of cotton growing vary considerably; in one State alone (Sao Paulo), three different varieties of cotton are reported, namely, Upland, Egyptian, and Sea Island.

Two different varieties of cotton seem to be chiefly grown, and these are of radically different type. The one is a tree cotton, known as Creoulo or Maranhao cotton, which yields well for several years and bears open bolls almost all the year round. The lint of this tree cotton is of very good quality, and the plant is said to be drought-resisting and to enjoy a remarkable immunity from insect pests, in marked contrast to all other tree cottons throughout the world. The other is the ordinary short-stapled herbaceous cotton, and is chiefly grown in the coastal districts where the rainfall is more reliable. The lint from these two species varies greatly in length from three-quarters of an inch to an inch and a half, but the average is about 1 in. to 1¼ in. The careless mixture of different staples is almost universal. The general character of Brazilian cotton is good; it possesses a peculiar harsh or wiry character, which makes it specially suitable for mixing with wool. It is generally badly handled in picking and ginning, only saw gins being used.

Peru

The conditions here are markedly different from those above described, and, indeed, Peru may be regarded

as the exception to the rule of the unsatisfactory conditions of cotton growing in Latin-America. Cotton is grown entirely under irrigation, as the climate is practically rainless ; but the water supply from the rivers—snow-fed from the mountains in summer—is ample, and only the lack of funds for irrigation works seems to stand in the way of large developments of cotton growing. The climate is favourable, being free from violent extremes of heat or cold ; while transport facilities by the rivers are naturally good, and have been augmented by railways.

The varieties grown are chiefly two, known respectively as Smooth Peruvian and Rough Peruvian, the former being about 65 and the latter 30 per cent. of the total crop. The former is usually grown as a biennial, while the latter is perennial. A small quantity of Sea Island is also grown, though of rather inferior quality ; and in recent years an increasing quantity of Egyptian cotton has been grown from imported seed.

In the southern part of the American Continent, especially in the Argentine, there are enormous areas which might produce large crops of cotton, and many successful experiments have been made, but the difficulty of the labour supply seems to prevent the development on a large commercial scale of a crop which requires so much labour for its cultivation.

Africa—Egypt

The outstanding characteristic of the Egyptian crop is that it is entirely grown under irrigation, Egypt being practically rainless, except for a slight winter rainfall along the Northern coast. Thanks largely to the excellent regulation of the water supply to the plant which is thus rendered possible, also to the

magnificent deltaic soil of which the whole country is composed, and the generally favourable and dependable climate, the Egyptian staple is the second best in the world, and the whole conditions of the crop are, on the whole, the most satisfactory of any country. The yield is extraordinarily high ; it has exceeded in the past 500 lb. of lint per acre, and the whole methods of cultivating and handling the crop were until recently a model to the cotton growing world. This is largely due to the fact that the labour supply is ample and in its own way exceedingly good ; while the commercial handling of the crop from the field to the ship's side is in the hands of a small number of large European firms, who are practically combined, and who see to it that the crop is picked, ginned, baled, compressed, and exported in the best possible condition, with the result that the Egyptian bale is probably the best in the world.

The chief varieties now grown have already been mentioned. The latest, Sakel, has rapidly taken the place of the former most common variety in Lower Egypt, namely, Afifi or Brown Egyptian ; but it has for some time shown signs of going the same way as all its predecessors—deterioration in quality.

The prospects of the Egyptian crop were, until a few years ago, exceedingly bright, and the crop was making steady progress in quantity, but this has, unfortunately, been very seriously checked during the last few years, mainly owing to a new insect pest, the pink boll worm. Great schemes of drainage, irrigation and reclamation were on foot which would have resulted in a considerable increase of the crop, but these were suspended on the outbreak of the war. There is now little hope of the Egyptian crop touching its 1913 record again for some years to come.

SUDAN

In the Sudan there are enormous prospects of development, especially in the Gezira district between the Blue and White Niles; but, in addition to the expenditure required on irrigation works, the development of this area will take time to replace the population destroyed by the wars of 1883–98. The Tokar area on the Red Sea coast is doing very well, and could be greatly improved by expenditure on railway irrigation works.

EAST AFRICA

In Uganda, again, there are great possibilities, but the difficulties of communication and labour supply, which are the great stumbling-block to the development of all our interior African colonies, will probably prevent any really great development there for a good many years to come. The largest crop yet reported was that of 42,000 bales in 1914, and there is no likelihood of that figure being even doubled in the immediate future. Similar difficulties are delaying progress in Nyasaland, where there can be no question of the possibilities of the country, but much will require to be done in the way of improving railway and river communications before the present crop of less than 10,000 bales per annum can be materially increased.

WEST AFRICA

The magnificent pioneer work of the British Cotton Growing Association in West Africa, as well as in the other African colonies already mentioned, has proved the possibilities of the country beyond doubt. But the provision of communications and the gradual opening up of the country will require a great deal of time and money, and the rapidity of progress has hitherto been checked by the fact that the local variety of cotton

was just not quite good enough to make a really conclusive comparison from the point of view of the grower's profit with other competing crops, which have the great advantage of requiring less care and labour for their cultivation. Within the last year, however, the situation seems to have changed very markedly in Northern Nigeria owing to the introduction of a new variety, which gives a much better return because of its higher yield and ginning outturn and better quality. The area available in Northern Nigeria is immense, and it may be hoped, now that the corner has apparently been turned, that future development will be much more rapid.

India

India suffers sadly from her evil reputation in the matter of cotton growing. As a matter of fact, India to-day is growing from 250,000 to 500,000 bales of cotton similar to American in quality and of nearly an inch in staple, sometimes more, which is quite fit to be used in Lancashire, and which is, as a matter of fact, very largely used both in India and in Japan at the present time in place of American. It is largely the question of the condition of Indian cotton that tells so strongly against it in English markets. But the inferiority of the staple is a more serious matter. The ancient tradition of the Dacca muslins is to the effect that cotton as fine as 300's was habitually produced in India long ago. Even allowing for the exaggeration of tradition, it is difficult to reconcile this statement with the fact that the great bulk of the Indian crop to-day is only about $\frac{3}{8}''$ to $\frac{5}{8}''$ staple.

The Indian cotton area is immense and very widely scattered; in 1914 it was over 25,000,000 acres, and there is still room in the future for a considerable

increase (*e.g.*, as the result of irrigation schemes in the Punjab, and also by the gradual substitution of cotton for other crops). But the essential condition of that substitution is that the native cultivator must be convinced that cotton will pay him better than these other crops, which is doubtful, unless at high prices. This is due to many causes, of which the principal are the very low yield and the very poor quality of his cotton. In the former lies the real hope of a substantial increase of the Indian crop. The average yield over all India is only about 80 lb. per acre, as against about 200 in America and 450 in Egypt. The average in India could be materially increased in various ways, all of which would also tend to improve the quality and therefore the value of the crop. The chief are seed selection and improved methods of cultivation. In both these matters a great deal has already been done by the Government Agricultural Departments ; but it is admitted that something more is required. Hitherto the policy of the Government has always been to demonstrate to the natives the possibilities of improvement and to offer them facilities such as better seed, improved implements, etc., but never to *compel* any alteration in their present methods.

The methods of handling the Indian crop, for example, require drastic amendment. The system of small ginneries, which is prevalent almost everywhere, owned by natives who act as merchants, buying the crop locally, and re-selling to the larger firms in the exporting centres is bad ; and there is a growing conviction that the Government will require to interfere by introducing a system of licensing and control of the ginneries, to prevent damping, fraudulent mixing, and the careless ginning and handling of the crop. If this were done, the Government might do a great deal more

in the way of seed supply than it has hitherto attempted, particularly by showing on a large scale by a model seed farm and plantation how good cotton can be grown and handled and disposed of in India. Certain districts have done a good deal already in the way of seed supply and in the direction of assisting the growers to find the best market for their crop, for one of the greatest difficulties of the improvement of the crop is that of securing adequate remuneration for the cultivator who tries to improve his crop by using good seed.

In so large an area, extending over nearly 30 degrees of latitude from Peshawur to Tinnevelly, the variations of climate are enormous, and at certain seasons of the year cotton is being both sown and harvested in different parts of India at the same time. Local conditions of soil and climate also vary greatly even between districts quite near each other, so that the variety of cotton best suited to one district may be quite unsuitable to another. The best varieties are grown in Madras, and in the Broach and Surat Districts of Bombay Presidency. Cotton of American type is grown in Southern Madras (*e.g.*, Cambodia), and in Dharwar (South Bombay) and the Punjab. On the whole, cotton is a " monsoon " or rain-grown crop throughout India; but in the Punjab, irrigation is almost universal, the rainfall being quite insufficient, and in practically all provinces the rainfall is supplemented by well irrigation.

The methods of cultivation are, on the whole, very primitive. Fertilizers, for example, are little used, and the introduction of improved agricultural implements, even of the simplest kind, is necessarily slow, though the Departments of Agriculture have done excellent work in this direction. Co-operative methods have proved successful in certain districts, but the difficulties

of making any radical change in general methods throughout a country so large and so conservative as India are enormous.

Russia and China

The only other areas that remain to be mentioned are Russia and China. In Russian Turkestan, and in the region between the Black Sea and the Caspian, Russia possesses a most promising area for cotton growing, which is already giving a crop of well over a million bales. The conditions are more similar to those of Egypt than of any other country, as cotton is largely grown under irrigation. The staple is good, much of it being about the quality and length of American, though the native varieties which are still grown in considerable quantities in certain parts of the area are similar to the short staple Indian varieties. The prospects of development are very good, and it appears that the Russian crop alone throughout the world has been making rapid strides during the war. The latest report gives the crop as 1,500,000 bales in 1916.

China is the unknown quantity in the world's cotton supply. Her crop is certainly large, but the very high figures which were semi-officially circulated a few years ago giving totals as high as 5,000,000 bales, are now generally discredited. The area under cotton seems to be widely distributed over many parts of the country, and is still capable of large extension. Probably the greater part of the crop is used for domestic consumption in the wadding of garments and domestic spinning; but a considerable amount is exported to Japan, and a good deal is now being used in local factories in China, which have been developing rapidly in recent years. The quality of the staple is mostly short, more like

Indian than anything else, but efforts have been made with marked success to introduce American varieties which seem to do well. The same applies to Corea, in which Japan is fast developing a promising source of supply for her own mills. The crop in Japan itself is very small and apparently dwindling in amount.

The British Cotton Growing Association

No description of the world's cotton supplies would be complete without a reference to the work of the British Cotton Growing Association. In the closing years of the nineteenth century, the situation with regard to the supply of cotton had begun to give rise to considerable anxiety. Already in 1900 the Germans had begun to develop cotton growing in their African colonies. The first step which led to the formation of the British Cotton Growing Association was taken by the Chamber of Commerce at Oldham in January, 1901, when a committee was appointed to make inquiry into the possibilities of growing American cotton in other countries, and particularly within the British Empire. The committee's report published in November, 1901, was favourable ; and on 18th February, 1902, the matter was further discussed at a representative meeting held at the Manchester Chamber of Commerce, when an influential committee was appointed. In the meantime, the late Sir Alfred L. Jones had taken up the matter on his own account, and in May, 1901, had sent out 10 tons of American seed to the West African colonies. On 7th May, 1902, Mr. J. Arthur Hutton, Acting Chairman of the West African Committee of the Manchester Chamber of Commerce, invited Sir Alfred Jones and some of the leading West African merchants to dinner at the Albion Hotel, Manchester, and at that dinner the British Cotton Growing Association was

born. At a general meeting of the various associations and other bodies interested, held at the Manchester Chamber of Commerce on 12th June, 1902, the Association was formally inaugurated, Sir Alfred Jones being elected President, and it was decided to raise a guarantee fund of £50,000. A fair response was made to the appeal for funds, considerable subscriptions being received from the organisations representing the cotton operatives, as well as from the employers.

The Oldham Committee had already, through the Colonial Office, instituted inquiries into the possibilities of cotton growing in our various colonies, and these were now followed up by sending consignments of seed and machinery to various countries which had been pointed out as suitable for experiment, and by grants to planters and others, while experts were sent out to various parts of the British Empire to inquire into their possibilities. The results were so satisfactory, that, in November, 1903, it was decided to increase the guarantee fund to £100,000. At this stage the matter suddenly acquired increased importance from the peculiar conditions of the cotton market, due to Sully's "corner," the price of Middling rising from 5¾d. in November to nearly 9d. in January, 1904. Under these circumstances, the Association decided to increase their capital to £500,000. In the King's Speech at the opening of Parliament on 2nd February, 1904, the situation was referred to in the following passage: "The insufficiency of the supply of the raw material upon which the cotton industry of this country depends, has inspired me with great concern. I trust that the efforts which are being made in the various parts of my Empire to increase the area under cultivation may be attended with a large measure of success"; and the interest thus shown in the matter in high

quarters was further proved by the grant of a Royal Charter to the Association on 27th August, 1904. It only remains to add that of the capital of £500,000, all but a few thousands has now been raised.

The Association in its early years did good work in calling the attention of the Indian Government to the possibilities of the development of the Indian crop. Its work in East and West Africa has already been referred to, and the development of the Sea Island crop of the West Indies has been largely due to the Association. It has also given valuable assistance in the encouragement and development of cotton growing in areas already established, such as Egypt and the Sudan. The experience of the Association has proved that the best policy to adopt in dealing with native cotton growers is to encourage them to become independent cultivators of their own land rather than to attempt large plantations under European management with the natives as paid labourers.

In addition to the experimental work and educational propaganda, the work of the Association has been to provide and maintain modern ginneries in different areas; to establish, where possible, a buying system at a fixed price, which would secure to the grower a reasonable and safe remuneration; and to stimulate the various governments in providing railway and other transport facilities—for the difficulty of transport has so far been, and will probably continue for many years to be, the limiting factor in the development of cotton growing in new countries, especially in Africa.

CHAPTER III

THE SPINNING MILL

Defects in Cotton

It is extremely important in proceeding with the manufacture of cotton cloths that a thorough knowledge should be gained of defects found in cotton. The following are some of the principal: Variation in length of staple; variation in diameter of fibre; weak fibres; rough, harsh intractable staple; bad colour; insufficient lustre or bloom; large percentage of sand, dirt, leaf, shell, seeds, small pieces of broken seeds with fibre attached to them, called Bearded Motes, neps, dead and unripe fibres, also fibres with few helical twistings owing to the cotton being grown under bad conditions. All the above defects have a deteriorating effect upon the value of cotton.

The longer the staple, providing the fibres are regular in length, the finer the fibre with the least percentage of the above defects, and the higher the price of the cotton.

Boll stained or tinged cotton, sun-dried cotton, also staples which have been damaged by frost, insects, etc., have a lower value.

The strength of individual fibres varies considerably; some fibres have a breaking strain of 46 grains only, whilst others will bear 212 grains before breaking. From this statement it will be seen that only a small percentage of the actual strength of the fibres in any cross section of yarn is utilised in offering the resistance to breakage, so that much depends upon the twisting

together of the fibres so as to prevent actual sliding of fibres over each other when a thread breaks.

The testing of cotton fibres is often done by pulling the staple by the fingers, which gives a simple means of arriving at the commercial value of any sample of cotton.

Microscopical tests are useful in comparing the relative spinning qualities of cotton, as it can then be seen whether the fibre possesses many helical twistings or not, and whether the fibres are dead, undeveloped, or unripe, owing to being grown under unfavourable conditions.

Other tests, such as burning the fibres and threads, are sometimes used to ascertain if yarns contain cotton, wool, or silk. The difference in the smell of these fibres when burning is easily distinguishable. Owing to cotton being a vegetable and wool an animal fibre, it is possible to dissolve the cotton fibres from any woollen yarn or fabric.

In most of the spinning mills of this Kingdom cotton is spun for sale as yarn; in others, owned by manufacturers, twist and weft are produced for consumption in the weaving sheds, the surplus yarn being sold or the deficiency made up by purchase. Good management is indispensable to success. The sequence of processes down to the minutest details must be perfectly familiar to the manager, who has to be able to so co-ordinate the productive system that the greatest weight of yarn is got off within the hours of running, at the least cost, quality of staple, of course, being a dominating factor. The managers and overlookers of the present day are technologically trained in the institutes and textile schools, which have become part of our educational system. The erection of a spinning mill is an expensive undertaking, and may be roughly computed to cost

about 25s. per mule spindle. The wages of the operatives in the cleaning, carding and spinning departments are in most cases arranged between the masters' and the workpeople's organisations, and the British cotton operatives are absolutely unrivalled for manual dexterity, intelligence and efficiency. Localisation of particular industries is among the phenomena of British industrial life. For instance, the Manchester and Bolton districts hold the predominance in fine spinning, though the production of fine counts of yarn has somewhat rapidly proceeded of late years in other towns—Oldham, Preston, etc. The Oldham and South-east Lancashire cotton towns are the greatest industrial areas of England in which American cotton, from which medium counts are spun, is consumed. Like good fruits, yarns improve with a certain amount of keeping.

Yarn kept for some days in a damp cellar or conditioning room improves in strength and working qualities generally. The natural tendency to snarl is taken out of the yarn, and it is thus rendered easier to handle at the next process. The natural moisture extracted during the opening operations is also returned to the fibres in the conditioning room. In yarn, strength, evenness, elasticity, and good colour, are essential.

The following cotton mixing table for first-class qualities of yarn will be of value—

Under	12's	Twist	Bengal Sind broken up cop bottoms, Fly and strips from card.
,,	15's	,,	1 Bengal, 1 Smyrna and 1 Chinese, either separate or mixed together.
,,	20's	,,	1 Dharwar, 1 Dhollerah or Oomra or Tinnevelly, or lower grades of American.

Under 30's Twist	Better grades of Indian with the strong low classes of American.
„ 40's „	The Middling grades or Texas mixed with Rough Peruvian or any Brazilian cotton in small proportions, never more than one-third.
„ 50's „	Good Fair Brown Egyptian or higher grades of American cotton, mixed with not more than one-third Maranhams, Santos, Pernams.
„ 60's „	Fully good fair brown Egyptian.
„ 80's „	Good brown Egyptian alone or mixed with Joannovich or very good Abassi. Brown Egyptian is often spun alone owing to its colour. When mixed with other cotton there is a danger of producing pinrowed, striped or streaky yarn.
Under 90's Twist	Combed Brown Egyptian, Joannovich or Abassi mixed.
„ 100's „	and Upwards, Combed Sea Island.
	Weft Counts would be spun one-fourth finer than twist from same mixing.

When it is intended to bleach the goods in which the yarn is used, the colour of cotton is of no moment. Yarns made from waste are always used for weft.

To test the quality of a mixing, one may take a vertical section of the stack so as to get an even lot. Pass it through every spinning machine in the mill, then test the yarn and compare it with the standard quality generally kept in stock to see that it is up to the required strength, colour, cleanliness, counts, etc.

To test cotton and yarn for moisture, it is usual to

weigh about 100 lb. and dry at about 100° F. This is generally done in the boiler or engine house for one or two days. Afterwards it is put in a room for a day at about 75° F. to regain its natural moisture. Then it is weighed again. If it is then found to have lost more than 3 lb. or 3 % it is evident that moisture has been artificially added.

A special oven is now used for drying yarn and cotton when testing for moisture.

We will assume that cotton has been bought at Liverpool to suit the needs of the spinner, and that the bales are duly delivered at the mill.

Let us proceed to the first treatment of the raw cotton. After it is delivered to the spinning mill, the bales are weighed and a few of them opened and examined to see if they are right in quality, according to the sample from which they have been bought. The mixing together of different varieties and staples of cotton is essential in order to get the average quality of the cotton used. Mixing, too, brings about more uniformity in the quality of the yarn. Cotton of long, strong, and cohesive staples is best adapted for twist, and cotton possessing these spinning qualities in a less degree, is used for weft.

A twist yarn forms the foundation of the cloth and has to stand the strain put upon it in winding, warping, sizing, and weaving, and on this account it has to be a strong, smooth, cohesive yarn. A weft yarn forms the covering or " feeling " for the cloth and requires to have a soft, silky, oozy feel and appearance. It is not necessary for the weft to be as strong as the twist yarn because the former is taken direct to the loom and is subjected to very little strain.

There are two ways of mixing : (1) by the hand, or (2) by machine. In the latter case a certain amount of cleaning is secured by the action of the machine.

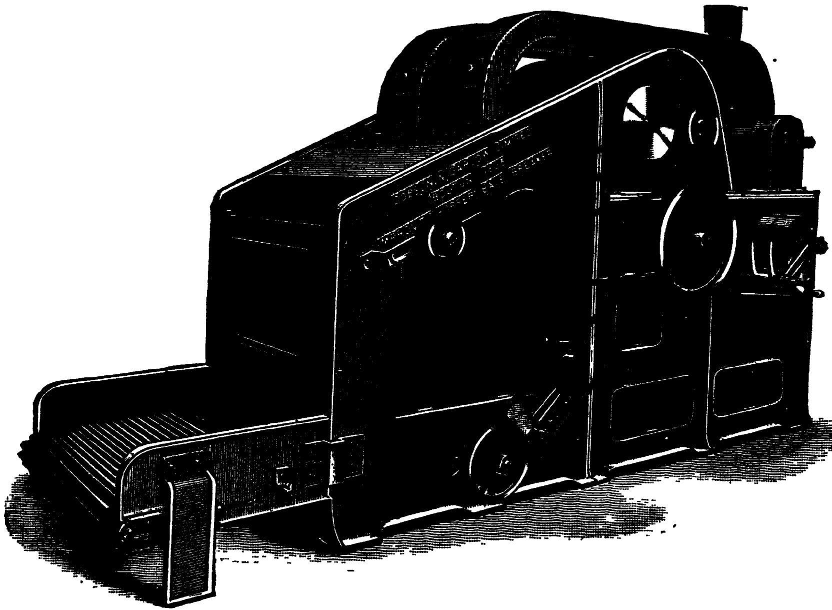
In the former there is no cleaning. The advantage of hand-mixing is that you get the cotton better blended, and thereby secure more uniformity in the quality of the yarn, but the cost of production is increased thereby.

Bale Breaker or Mixing Machine

If the cotton is mixed by machine it will be done either by the Roller Bale Breaker or Hopper Bale Breaker. The latter machine has largely superseded the former, as it opens and cleans the cotton better and more cheaply. The Hopper addition to mixing and scutching room machinery is the greatest improvement made in recent years. The Hopper Bale Breaker is very strongly built, and consists of a Hopper box into which the feed lattice drops the cotton. Or large armfuls may be thrown direct into the Hopper box, at the bottom of which is a short floor lattice which delivers the cotton to an inclined spiked lattice moving upwards at about an angle of 35° from a vertical line. The spikes of this lattice take hold of the cotton and carry it upward. Near the top of this lattice is an evenning roller, which combs out any large pieces. At the rear of the spiked lattice is a stripping roller which clears the lattice, the cotton falling on a short lattice near the bottom of the machine. This carries the cotton to a pair of inclined or vertical lattices which presses the cotton between them. These lattices carry it upwards and drop it on another lattice, from which, by other lattices and a reversible arrangement, it can be distributed to any part of the mixing room. There may be as many as six mixings in the room.

Cotton Opening

The mixed cotton is taken from the stack, in vertical sections, so as to get mixed in every armful a small



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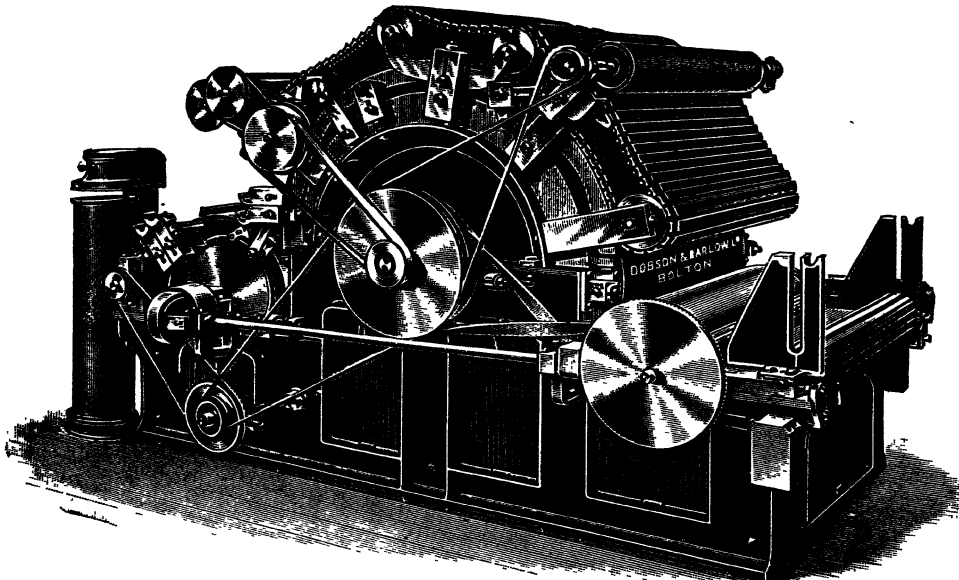
BALE BREAKER

portion of cotton from each bale. This is with the object of securing uniformity in the yarn. A mixing that will last a week is preferred to one that will last a day, and whilst one mixing is being used another is in process of making. This gives time for the evaporation of any dampness that may be in the cotton. The cotton from the mixing is generally placed upon a travelling floor lattice of sufficient length to suit local conditions. This carries the cotton forward into a Hopper feeder box. The object of this feeder is to pull the cotton finer and to clean it a little, but principally to deliver it upon the Porcupine Opener feed lattice in an even sheet. The feed lattice carries the cotton to a pair of feed rollers, from which it is struck by a Porcupine cylinder about 36 inches diameter and 45 inches wide, and run at about 500 revolutions per minute. The force of the blow given to the cotton by the beater drives it against dirt bars, set in a circular position underneath the beater. Whilst dirt is driven out the cotton is carried forward by the strong air current through dust trunks. If damp cotton is placed in the opening machines it causes them to choke up, and also tends to string, and nep the cotton, whilst the dirt does not come away as when the cotton is in a dry state.

The dust trunks are about four feet long, 12 inches wide, and ⌓ shaped. As the cotton passes through, the dirt falls down between thin plates. At the base of the trunks there are hinged air-tight doors which are opened once or twice a day to remove the accumulations. There are generally about half a dozen of these dust trunks or dirt boxes in the range between the Hopper and Opener, the number varying according to the space available. From the trunks the cotton enters into another beater chamber, where another beating and cleaning process goes on. Then it is collected by a pair



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REVOLVING FLAT CARDING ENGINE

of dust cages, drums made of perforated sheet metal, on fine meshed wire netting. The ends of the cages are open to a dust flue, down which a fan forces a strong air current. This produces a partial vacuum inside the cages, causing the cotton to fly on the outside of the cages, whilst the fine dust and impurities pass through the perforations into the dust flue below. It is important that the construction of the flues offers no obstruction to the passage of the air. The dust cages pass the cotton on to pairs of cage rollers, and then on to one or two pairs of feed rollers, from which it is struck by a two or three-bladed beater revolving at a rapid rate. A two-bladed beater revolves at about 1,300 revolutions, and a three-bladed beater at about 900 revolutions per minute. These beaters are very carefully made, well finished, strong, and perfectly balanced. The edges of the striking blades are bevelled to a point, so as to open and clean the cotton better. After these beaters have been working a number of years the bevel edge gets worn off and has to be resharpened or replaced. For the finer and better qualities of cottons some prefer the three-bladed beater for the reason that you get the same number of blows given to the cotton per minute as you do with a two-bladed beater, and the force is therefore less. This is an advantage for finer cotton.

The beater strikes the cotton against the dirt bars. The dirt, being heavier than cotton, takes up a greater percentage of the energy of the blow given by the beater and is consequently driven out. The cotton is carried forward by the air current rushing through the spaces in the dirt bars and delivered upon a second pair of dust cages, which collect the cotton into sheet form. Then it is passed on to the cage rollers and calender rollers consolidating the sheet so that the liability of " licking "

at the next process will be less. From the calender roller the cotton sheet is delivered to the lap rollers, which wind it up into lap form and by means of a lap-compression motion, which consists of a rack, train of wheels and brake-pulley, the lap is wound up very tightly and is easy to handle at the next process. The production of a Hopper Bale Breaker is very great.

The production of a Hopper Feeder is the capacity of the opener to take the feed and amounts to about 30,000 lb. per week of fifty hours.

The Scutcher

The object of the scutcher is to further clean and open the cotton, and also to improve the regularity of the opener laps. It used to be a common practice to have an intermediate scutcher for American cotton, but since the introduction of the Hopper Feeder, the intermediate scutcher is not considered necessary. The less you can beat and work cotton, so long as you get it clean and sufficiently opened for the card, the stronger yarn you get.

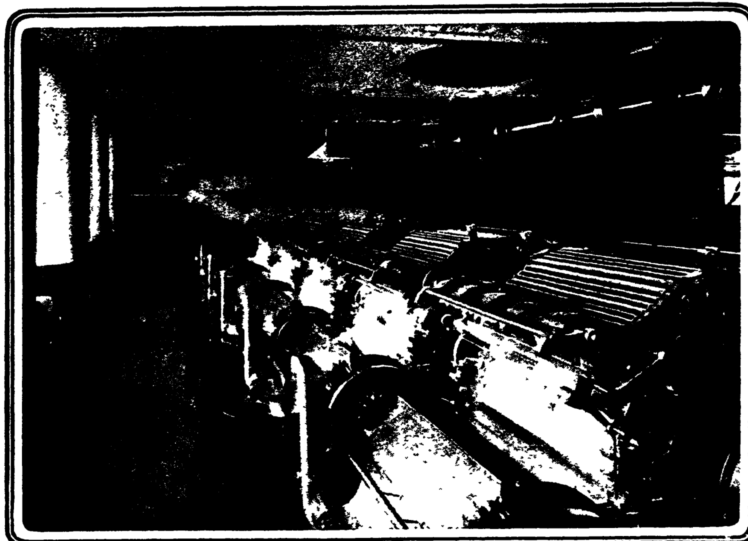
The Opener lap, which generally weighs about 40 lb., and is about 45 yards long, is put upon the feed lattice of the scutcher. Generally four laps are doubled. This helps to make the finished lap more uniform in weight yard per yard. The doubled laps are fed to two pairs of feed rollers, or one pair of feed rollers and another roller with pedal levers under the roller which forms part of the piano-feed motion. From these rollers or pedal nose the cotton is struck by a heavy revolving beater. Dashed against the dirt bars, the impurities in the cotton fall through. The cotton collected by a pair of dust cages, passes to a pair of conducting rollers, and four lines of calender rollers, which compress the

sheet of cotton, after which it is wound up in lap form ready for the carding engine.

There are several motions about a modern scutcher which require dealing with separately, such as the piano-feed motion, knocking-off or measuring motion, the arrangement for weighting the calender rollers, and the driving of the different parts of the machine.

Piano-feed Motion

The object of this motion is to regulate the speed of the feed rollers to compensate for any variation there may be in the thickness of the opener laps. The motion consists of a feed roller, under which are placed a number of pedal levers. The nose of the pedal is specially shaped (if the cotton is struck from it) to suit the length of the fibre, so as not to damage the cotton. If the cotton is not struck from the pedal nose, but from a pair of feed rollers, then the regulating pedal is placed behind the feed rollers and does not need to be specially shaped at the nose. Whichever may be the case, the pedal lever is fulcrumed several inches from the nose. The tail end of the lever, of which there are about sixteen, is hooked, so as to hold a vertically hung pendant lever, the lower end of which is wedge-shaped Δ. These wedge-shaped parts hang between antifriction bowls. The end pendant is slotted and to it is connected a lever which, through a connection of levers, acts and moves a leather belt which drives the feed roller through a train of wheel and cone drums. If a thick place in the lap comes under the feed roller it depresses the pedal lever, swivels round the fulcrum, lifts up the tail end, which also raises the pendant lever, and through the bowl box to the last lever in the series and onwards, to the cone drum belt, thus moving the position of the belt



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CARD ROOM, SHOWING MOTOR

on the cones to drive the feed roller slower and compensate for the extra thickness going through. If a thin piece is going under the feed rollers the opposite effect is obtained. The feed roller is speeded up to neutralise the thin place.

The greatest defect in connection with the piano-feed motion is the trouble of having to clean the bowl box out every few weeks, also the bowls sticking and flat places wearing on them. If the bowl box is not kept clean and the bowls in good condition, there is neutralised the object of the motion. Many different arrangements of bowls have been tried with a view to reducing friction in the bowl box, and a few years ago one important machine-making firm introduced an arrangement to discard the bowls and bowl-box altogether, and substitute a tripod arrangement of levers and links. This method has had a very wide adoption and is giving satisfactory results.

In some of the old scutchers there were two calender rollers, but in all modern machines (unless specially ordered) there are four calender rollers. The four calender rollered machines give better consolidation to the laps. The calender rollers are also made with a slightly different surface speed so as to polish and smooth the consolidated sheet of cotton. It is important that all lap rods used for laps should be exactly the same weight. If they are not, one is led astray in weighing the full laps.

On most openers there is a knocking-off motion, but this is not used when there is a pressure for laps, thus increasing the production of the machines. The finished laps at the scutcher weigh about 30 lb. each, and any lap weighing 4 oz. lighter or heavier than this standard weight should be rejected for irregularity. In some cases these bad laps are sent back to the mixing

room, or a heavy and light lap may be put on the creel of the scutcher lattice again and made into a fresh lap.

It is not absolutely certain because the total weights of the laps are equal that they are good laps. Generally speaking, this would be so. At the same time, it is possible the total weight of the lap is right, but the lap yard per yard very irregular. Owing to this being possible, there are wooden gauges for measuring off two-yard lengths. The whole lap is sometimes measured in two yards and re-weighed. If the lengths then weigh equal it is proof that the machine is working well.

In both scutchers and openers it is important that all parts should be kept well oiled and cleaned. If this is not properly attended to there is the liability to fires, irregular laps, lap-licking or splitting, and bad selvedges. All parts of the machine with which the cotton comes into contact should be periodically black-leaded, to make them smooth, so that the cotton may not adhere.

Carding

The object of the carding engine is (1) to remove all impurities either natural or foreign in the cotton which have escaped the preceding processes ; (2) the extracting of all short, immatured, broken or nepped fibres, the retention of which would weaken or otherwise reduce the quality of the yarn ; (3) to disentangle the confused mass of fibres and lay them approximately in parallel order ; (4) to attenuate or draw out the heavy sheet of lap into a thin fleece or film and contract it into a ribbon of cotton or sliver, fitted for the next process.

The impurities are husks, shell, seeds, bearded motes, leaf, neps, and dead or unripe cotton. The whole, or

most of these impurities, are forced into the card wire, and periodically stripped out by a comb, working in connection with the flats. A brush strips the impurities from the cylinder and doffer. The short fibres not being of sufficient length to be held by the card teeth are thrown off, in the flat-teeth, or through the undercasing of the licker-in, or cylinder.

The drafting and the collecting of the fibres from the doffer, and guiding them through a funnel, and calender rollers, constitutes the making of the web into a sliver.

Bearded motes, neps and leaf are the impurities most difficult to extract in the card. Bearded motes are unginned broken seeds, and broken seeds which have short hairs on them after ginning. The short hairs on the outside of the broken seeds stick to the cotton and are difficult to extract.

Neps are a small number of fibres rolled together, forming a ball about the size of a pin-head. These neps may be caused by bad ginning, overbeating at the scutchers, or bad carding, and they adhere to the cotton tenaciously.

Leaf is very light, breaks up into fine pieces, and is very difficult to get rid of. It is only by subjecting the cotton to the process of combing that perfectly clean yarn is obtained.

Many years ago there used to be a system of double carding. This is now obsolete and has been superseded by the Revolving Flat Card and the Comber. The Revolving Flat Card gives double the production to that of a Roller and Clearer Card, with a better carded sliver, more cheaply produced.

Let us now see how the cotton lap is further opened and cleared in passing through a Revolving Flat Card.

The scutcher lap is placed upon a fluted lap roller.

The end of the lap is guided under a feed roller about 2 inches in diameter. Under the feed roller is a dish-feed plate, the nose of which is curved to suit the curvature of the feed roller, and the length of the nose is made to suit the length of the fibre being carded. Whilst the cotton is held by the feed roller and dish-feed plate, the cotton is combed out by the teeth of the licker-in, the points of which are set to about $\frac{7}{1000}$ of an inch from the nose of the dish-feed. At this point the material is attenuated or drafted out about 2,000 times. so that the lap sheet is converted into a very thin fleece, Underneath the licker-in are two mote knives for clearing off the fragments of seeds on the surface of the fleece of cotton being carried round. On the points of the teeth of the licker-in, there are also dirt bars, where fine impurities and short fibres pass through into the dirt chamber below. The cylinder has about double the surface speed to the licker-in, and its wire teeth are bent forward in the direction of motion, and set to about $\frac{7}{1000}$ of an inch from the licker-in teeth. The cylinder strips the licker-in of its fibres and carries them on to the flats. Generally there are about 110 flats on a card, and forty-four of these are always carding, when the card is working. The flats wire has what is called a heel and toe, when carding. The wire where the cotton enters is about $\frac{1}{50}$th of an inch from the cylinder wire and is called the toe. The heel is where the cotton leaves the flat and is set to about $\frac{1}{100}$th of an inch from the cylinder wire. The object of this heel and toe in the flat wire is to allow the cotton to enter under the flat easily without rolling and forming neps, and the heel being nearer the cylinder wire gives the fibres a progressive carding. The flats are the main carding part of a carding engine. As the cylinder carries the fibres under the flats they tend, through centrifugal force, to fly out, and in doing so

come in contact with the flat teeth which combs and cleans the fibres from many of their impurities. After the cotton has passed under the forty-four flats it comes to a stripping plate, which separates the fibres as they leave the flats. Very much depends upon the setting of this plate whether there are heavy or light strips. The nearer this plate point is set to the cylinder wire, the lighter the strips will be. The cylinder carries the cotton onward to the doffer, which has about thirty times less surface speed than the cylinders. It runs in the opposite direction to the cylinder, and its wire teeth are set in an opposite direction to its motion. It is set to about $\frac{5}{1000}$ths of an inch from the cylinder wire and collecting the fine web from the cylinder, carries it underneath to the front, where it is stripped by an oscillating comb set close to the wire teeth. It is next guided to a trumpet mouth, which condenses the web into a cotton sliver. Then it passes through a pair of calender rollers and coiler rollers, down the tube wheel, and is wound spirally into the sliver can which runs in the opposite direction to the coiler and at a much slower speed. The variation in speed and the setting of the can-plate in relation to the coiler winds the material into the can, in a very beautiful manner. The object of winding it in, after this fashion, is to get a greater quantity of sliver into the can, and to enable it to be pulled out at the next process without entanglement and breakage.

The filleting for the card is made in lengths so that one length will cover the doffer or cylinder. The foundation of the filleting for doffer and cylinder is generally made up of one layer of woollen sandwiched by two outside layers of cotton cloth of very good quality. These layers are securely cemented together by india-rubber cement and finished off with a top layer of pure india-rubber.

The object aimed at is to get a firm foundation for the wire and at the same time to have a little elasticity in it. For the flats there is used the same foundation but without the layer of india-rubber at the top. It would not do to use the india-rubber for flat foundation, because the flat has no protection from the rays of the sun. The cylinder and doffer are more protected and cased-in than the flats.

Section of Card Wire

Many different sections of card wire have been tried for card clothing, viz., round, plough ground, flat, side ground, convex, etc. All the sections, except round and plough ground, have been discarded because of their weakness and working loose in the foundation. The object of these different sections is to supply a wire that will keep sharp at the point without having to be ground frequently, and also to provide more space between the wires for the accumulation of dirt, and thus reduce the need for frequently stripping out. Experience has proved that plough-ground wire (that is, wire of a round section, but ground down, the tooth almost to the knee) is all that is desired, though some people using the better qualities of cotton prefer the surface ground—that is, wire of a round section with the sides close to the face of the wires ground to a point.

The counts of card wire are based on the number of points in one inch length, and four inches width of the filleting. If you divide the number of crowns per square inch by $2\frac{1}{2}$ it equals the counts of wire.

Counts $\times$ $2\frac{1}{2}$ equals Crowns per sq. inch
" $\times$ 5 " points " "

so that if the counts of card clothing are 100's we should have 500 per sq. inch.

The counts of wire used for different cottons are—

	Cylinder	Doffer	Flats
Indian ..	100's	110's	110's
American ..	110's	120's	120's
Egyptian ..	120's	130's	130's
Sea Island ..	120's	130's	130's

The licker-in is generally covered with metallic saw tooth covering, and has about eight teeth per inch in width and four teeth per inch circumferentially.

Grinding of Cards

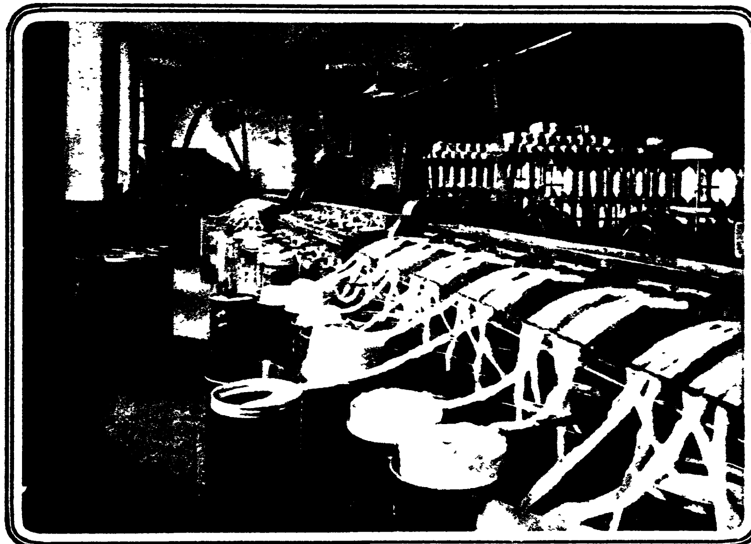
To ensure good work from carding engines the card-wire must be kept sharp. This is done by grinding the card-wire with revolving rollers covered with emery cloth. The rollers are made to have a lateral traverse, so as to grind the side as well as the top of the wire. Grinding each card once per fortnight for several hours should keep the wire in good condition.

Stripping-out of Cards

If the yarn has to be clean, the dirt collected by the cylinder and doffer should be periodically stripped out. The number of times depends upon the kind of cotton used and the quality of yarn desired. Generally speaking, for American cotton they strip out twice per day and for Egyptian cotton three or four times per day.

The stripping-out is done by placing a wire brush in bearings close to the cylinder and doffer, so that the long slender wire of the brush enters the cylinder and doffer wire about $\frac{1}{8}$ inch deep. The brush is revolved at a high speed by a rope and pulley, and it clears all the impurities from the wire. The brush is afterwards stripped out by hand.

There are many other details as to carding, on the efficiency of which the success or non-success of a mill



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FRAME ROOM

may depend so far as yarn production is concerned, but those described are the principal and illustrate fully the carding system.

Drawing Frame

The slivers from the card are now taken to the Drawing Frames, the object being to minimise the irregularities in the sliver by doubling a number of slivers together, and drawing them down to the same weight per yard as any individual sliver coming from the card. The action of the draft rollers, too, has the effect of making parallel and polishing the fibres in the sliver. This gives a very bright appearance to the sliver at the finished head of the draw frame. There are several reasons for the irregularity of the slivers. For instance, laps from the scutcher, fed to the cards, are far from being perfectly even. Then there is bad piecing of the lap at the back of the card, and it is generally known that after stripping-out the sliver runs fine for some time. To minimise the latter irregularity, the card is allowed to run a short time after stripping out, before piecing the sliver up.

There are two different arrangements of Drawing Frames, viz., the zig-zag and tandem. The former is very seldom used except in narrow mills. The latter is the generally accepted type because it is more convenient and is easy to work. The slivers at the draw frame, proceed through them, or form passages, according to the amount of doubling the cotton will bear, and the yarn requires. American cotton is generally put through three passages, with six slivers doubled together at each passage. This means 216 of a doubling. Egyptian and Sea Island cotton are generally put through four passages with six ends up. This would give 1,296 of a doubling. Some people double eight ends

up for the finer cottons instead of six, at the draw frame, but six ends up and four passages is the most common practice for good cotton.

Let us now see the passage of the sliver through the Drawing Frame. One end of the sliver is lifted out of the can, passed through a sliver-guide to prevent the doubled part of the sliver passing forward, then over a spoon lever, which forms part of a stop motion ; then over a sliver traverse guide, and through four lines of top and bottom draft rollers, which draw the slivers about six times finer. The draft in the four lines of rollers is differentiated. The first pair of draft rollers the cotton comes to has the smallest draft and each succeeding pair increases in draft. These draft rollers, both top and bottom, have clearers to keep the rollers clean. From the front draft roller it passes down to the funnel and calender rollers and drops down the inclined tube wheel into the can, which coils the sliver in the same manner as was described when dealing with the card.

Stop Motions

On all Draw Frames it is absolutely essential to have a good stop motion. In case any one of the six slivers at the back breaks, or a can runs empty, it is necessary that the frame should automatically stop or there would be five ends running instead of six, which would destroy the purpose of the machine. When a sliver breaks between the front draft rollers, and calender rollers, the machine must stop, or there would be a very large percentage of waste. Also when a can gets full the machine must stop or the coiler brackets may be broken. There are two different types of stop motions, one mechanical, the other electric. Both these stop motions provide for stopping the frame automatically, and both are largely used.

Weighting of Rollers

In order to get proper drawing it is necessary to weight the Draw Frame rollers. There are several different methods of weighting

It is necessary, if good work is desired, to have good top and bottom clearers. More experiments have been made in regard to clearers on the Drawing Frame than on any other machine. The clearer mostly adopted at the present day is the "Hermon," which consists of an endless piece of cloth stretched over two rollers made to revolve on the top of the leather rollers. An oscillating comb with very fine teeth rests upon the cloth and receiving a reciprocating motion from the rocking shaft, the comb keeps the clearer clean and the accumulated dirt is picked off by the tenter.

There are also clearers under the bottom rollers to keep the fluted roller clean. These clearers are also picked by hand several times a day.

Drawings

Some years ago there were introduced metallic top-drawing rollers for Draw Frames and Fly Frames. These rollers have had a fairly wide adoption for the Draw Frames in many of the mills that have been built recently, but very few have been put to work on the Fly Frames. The object of these metallic top drawing rollers is to save the cost and labour in putting cloths and leather upon these top-rollers. These rollers need much lighter weights than leather-covered rollers. The production for the same diameter and speed of front roller as a leather-covered roller is much greater, owing to the extra length got by the meshing of the flutes.

Fly Frames

The Slubbing, Intermediate, Roving and Jack Frames are known by the names of Fly Frames or Speed Frames. All depends upon the degree of coarseness or fineness required as to how many of these frames the cotton is passed through. For very coarse hanks there would only be the slubbing and roving. For medium hanks there would be slubbing, intermediate and roving; and for very fine hanks, slubbing, intermediate, roving and jack. The object of all these machines is the same; that is, to draw the material finer, twist it just sufficiently to unwind at the next process without breaking, and wind the material in bobbin form so as to make it convenient for handling at the next process. The only difference in these frames is that the slubbing, being supplied with sliver cans from the draw frame, needs no creel, and, as the hanks go finer, the gauge of the spindle rollers and lift and other parts of the machines need not be so great. These machines are driven by a belt from the line shaft, driving what is called the twist shaft. From this twist shaft every other part of the frame receives its motion. A wheel fast on this shaft drives the spindle shaft by a large carrier wheel, and fastened on the spindle shaft are skew bevel wheels driving the spindles. The twist wheel also screwed fast to this shaft drives the top cone drum shaft and front draft roller. The second and third draft rollers are driven from the front by gearing. The bottom cone drum which gives the excess speed to the bobbin and drives the lifter rail gets its motion from the top cone drum by a belt. The gearing of the driving to the spindles and bobbins is such that when the bottom cone drum is stopped the spindles and bobbins run at the same speed. It is this arrangement of speeds that enables the ends to run slack for doffing purposes. The

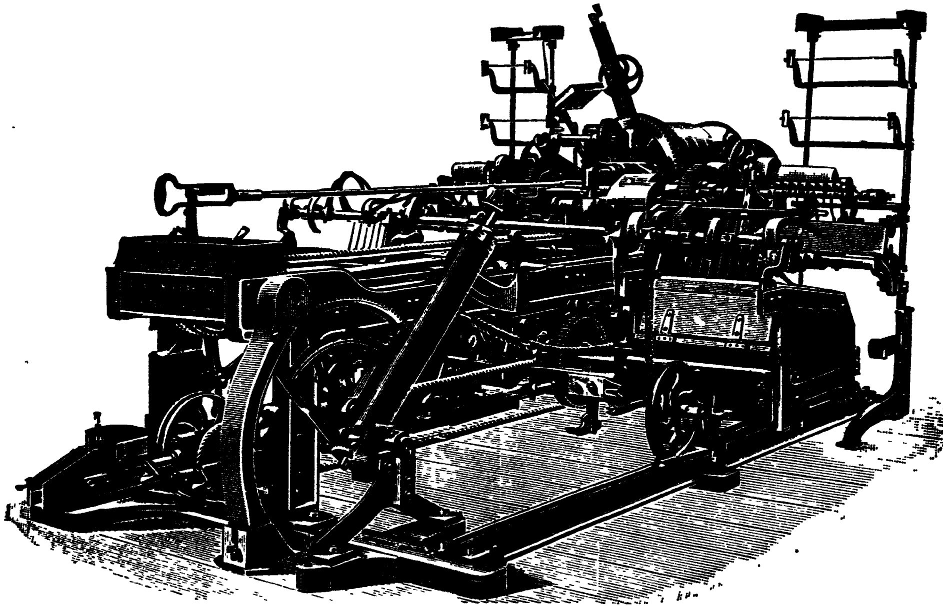
variable excess speed required for the bobbin to wind the material on is given to it by the revolution of the bottom cone drum. Variable speed is given to the bobbin rail, which is necessary to keep the coils of rovings equally laid.

Doublings at the Fly Frame

There is never doubling of ends at the Slubbing Frame because of the great difficulty in dealing with double the number of cans at the back of the machine. At the Intermediate, Roving, and Jack Frames, two bobbins are doubled to one end, to minimise the irregularity at the slubbing. We have the creels arranged at the next processes, so that it makes it very convenient to double. There are always single boss rollers at the Slubbing, but there may be single or double boss rollers at the Intermediate Roving and Jack Frames. Single boss rollers tend to better work. The advantage in using the double boss is that there is only required one-half the number of rollers, weights and weight hooks, and consequently less work in scouring and cleaning.

Standard Twist put in the Material at these Frames

It is impossible to give arbitrary rules for twisting the material at the Fly Frames, because the twist has to be varied to suit the character of the cotton and the working condition of the frame. Although the hank being made may be the same, what is done in these frames is to put as little twist in as possible, so long as the sliver pulls the bobbin round at the next process without breaking. If more twist is put in than is required the production of the frame will be reduced, the leather top roller will wear out sooner, and the drawing



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SELF-ACTING MULE

will be more irregular. That part of the Fly Frame which supports and carries the bobbin is called the collar. There are two different kinds used—long and short. There are two systems of winding the rove on the bobbins at these Fly Frames, namely, Bobbin-to-lead and Flyer-to-lead. The latter system is now almost obsolete; the former is becoming general. The cone drums on the Fly Frames, as well as the Scutchers, have to be concave and convex in form to give correct winding and feeding.

Spinning Machines

There are three different types of spinning machines, viz., the Flyer Throstle, Ring Frame, and Mule. The object of all three is the same—to reduce the rovings to the required fineness or counts, to give them an amount of twist, which depends upon the kind of yarn being made, and the purpose for which it is intended; also to wind the yarn upon a double-flanged bobbin on the Throstle frame, and on a bobbin without flanges if spun on a Ring frame, and on the bare spindle on short thin paper tubes if spun on the Mules. All these machines have three lines of top and bottom rollers, the bottom line steel-fluted and the front top line covered with cloth and leather, whilst the middle and top back rollers are generally highly polished, self-weighted rollers, without leather covering. Spinning machines generally have about 1·2 of a draft between the back and middle lines of rollers and from five to eight of a draft between the front and middle line. The latter is the break draft, and depends upon the counts and quality of yarn required.

Flyer Throstle Frame

The Flyer Throstle Frame is used exclusively for twist yarns up to about 40's. Yarn spun on this machine is

known and sold as " water twist " from the fact that the first machine was driven by a water-wheel. To spin yarn on the Flyer Throstle Frame a good class of cotton is required for the counts being spun, with plenty of twist, in order to pull the bobbin round in the spinning process. The method of winding the yarn on, in this machine, is the same as in the Flyer-to-lead principle in Fly Frames, with the exception that when an end breaks the bobbin stops, whereas in a Fly Frame it keeps on running. Yarn spun on these machines has a good reputation ; in fact, it is impossible to spin a poor, soft, weak yarn on these frames. Every inch of yarn is tested in strength on these machines by the yarn having to pull the bobbin round at about 5,000 revolutions per minute.

The Flyer Throstle Frame consists of a creel, sometimes a flat table creel and sometimes a vertical one, in which the roving bobbins are placed. The rovings are passed over guide rods and then through traverse guides and onwards to three lines of top and bottom drawing rollers to draw the material to the required fineness. When it emerges from the front draft roller it is passed down to a flyer which is screwed upon a spindle. The flyer twists the yarn and winds it on the bobbin.

Ring Frames

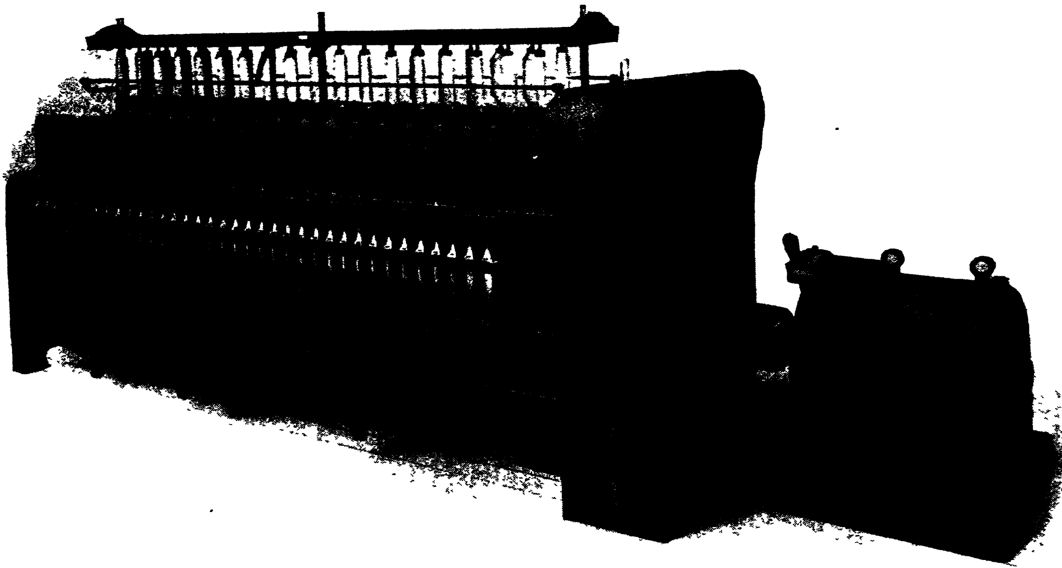
Comparing the three different systems of spinning, it may be said that the spindle speed in a Flyer Throstle Frame is only about 5,000 revolutions per minute. It takes more power for the same number of spindles, and there are fewer spindles in the same space as compared with a ring frame. It takes more time for doffing and more oil per spindle. The Ring Frame spindle revolves

in a bath of oil that will last without re-oiling for a number of weeks.

The Ring Frame spindles run at from 8,000 to 10,000 revolutions per minute, thereby giving a much greater production than the Flyer Throstle. The Ring Frame is a continuous spinner, the twisting and the winding go on simultaneously. The Mule is an intermittent spinner. It draws the roving and twists the yarn as the carriage comes out, but the winding on is done when the Mule is running in to the roller beam. The Ring Frame is a much simpler machine than a Mule. The Mule can spin a softer yarn than the Ring Frame, and upon the bare spindle.

The Ring Frame has made very rapid progress of recent years, both in this country and on the Continent, for the spinning of twist yarn up to about 60's and weft up to about 30's. The great defect in this machine is that the yarn has to be spun on a small bobbin or long thick paper tube. This prevents the yarn being used except on the premises where the yarn is spun, because it is too costly in carriage on broken bobbins, if the bobbins are returned. New mills that have part Mule and part Ring Frames have a reeling, winding and warping department, so that the yarns may be sent away in bundles or on back beams. In some cases manufacturers have thrown out their winding and warping frames and filled up this space with new looms, having found it to be more profitable to buy the yarn in back beam form and so increase their production by more looms.

The Ring Frame may be driven by a belt or rope from the line shaft. This drives the tin roller which in turn drives the spindles by a spindle band. Fixed upon the tin roller shaft is a compound wheel which drives through a train of wheels the cam which gives motion



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RING SPINNING FRAME, DRIVEN BY MOTOR

to the ring rail and shapes the yarn wound on the bobbin, and it also drives the middle and back draft rollers. The cam is so made as to cause the downward movement to be accomplished in one-half the time of the upward movement of the bobbin rail. This is designed to give a binding thread to the body of the yarn, which causes the yarn to come off more freely when unwinding.

The traveller of the Ring Frame which varies in weight according to the counts of yarn being spun, clips the ring and revolves one revolution every time the spindles make a revolution minus the retardation necessary for winding the yarn on the bobbin. The ring also varies in diameter according to the counts being spun. The finer the counts the less the diameter of the ring. The lift is also less for finer counts. The traveller puts the twist in the yarn as well as winding it on the bobbin by running slightly slower than the spindle. The yarn is wound on the bobbin after the style of building a cop at the Mule. On the rings' rail of the Ring Frame there are small pieces of wire with sharp edges set close to the path of the traveller when revolving round the ring. The object is to clean off the fibres and fluff that accumulate on the traveller and thereby improve the spinning.

Separators

The object of Separators, or pieces of plate projecting between the bobbins, is to reduce the amount of ballooning in the yarn caused by the revolution of the bobbin and traveller giving a centrifugal force to the yarn. The great defect in a Ring Spinning Frame and the one which has prevented its superseding the Mule to any large extent, is the fact that this machine cannot spin yarn commercially upon the bare spindle. Many experiments are now being made to secure this.

The Mule

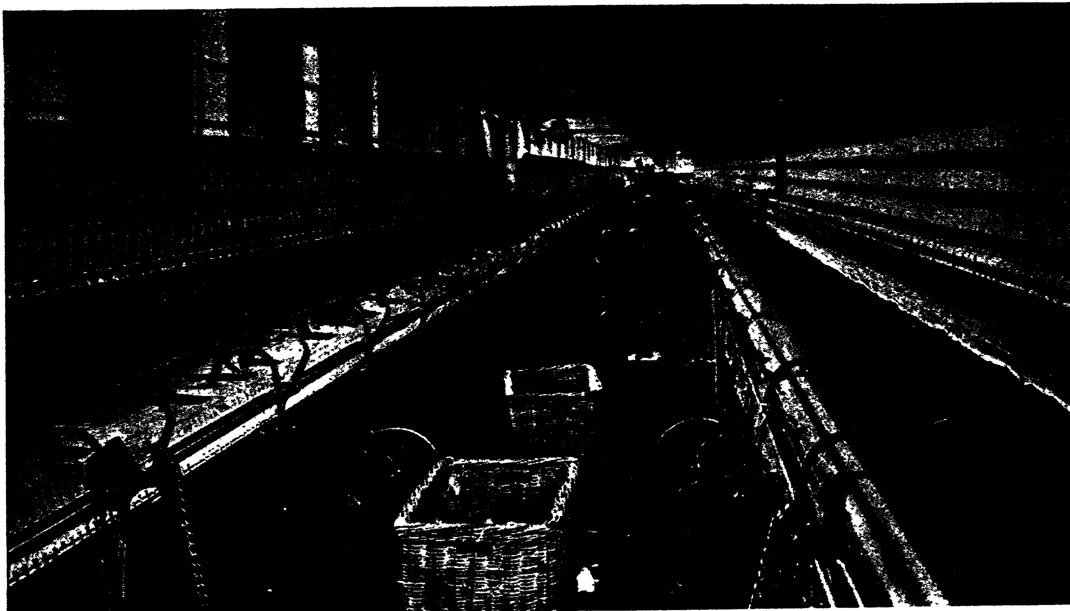
The object of the Mule is to draw the rovings into the required fineness, to twist the yarn to give it strength, and to wind on a short paper tube or on the bare spindle as may be required. In this machine there can be spun a softer yarn, from a worse class of cotton than the Throstle or Ring Frame because the machine handles the yarn more gently. Another feature of some importance is that in the Throstle or Ring Frame the yarn is wound on as it leaves the front draft rollers, but on the Mule the yarn can be made more level after it has left the front draft roller.

The modern Mule is much longer than Mules put in forty years ago, when a Twist Mule was about 750 spindles long and a Weft Mule 900 spindles long. To-day Twist Mules are made to contain about 1,100 spindles with a gauge of 1⅜ inch, and Weft Mules have now about 1,300 spindles of 1⅛ inch gauge. A full-size twist cop spinning 60's twist would be about 7½ inches long and 1¼ inches diameter. A weft cop would be 4¾ inches long and ¾ inch diameter spinning 80's. The finer the counts spun the shorter and less diameter will be the cop. The stretch of a Mule (that is, the distance the spindle point moves outwards each draw) varies according to the counts spun. The finer the counts, the less the stretch. For about 30's to 60's there is a 64 inches stretch and for finer counts as low as a 58 inches stretch. The larger the stretch the more is reduced the piecing capacity of the spinner, besides getting worse spinning. As large a stretch as is consistent with good spinning and management must be secured or the production is reduced. In many mills the draft rollers revolve during the time the carriage is running in, with a view to increasing the length of yarn delivered per draw by about 3 inches. This is equal to having a 3 inches

longer stretch so far as production is concerned but without the disadvantage of a long stretch. The spindles in a mule carriage do not stand up vertically but the points are inclined towards the roller beam. This is what is called bevel. In finer counts there is required more bevel than coarse counts. It is advisable to have as much bevel in the spindle as possible, so long as the yarn does not slip off the spindle blade during spinning, causing snarls. Snarls are loops in the thread and are very objectionable to the manufacturer.

There are many causes of bad spinning at the Mule, such as cotton not being good enough for the counts spun, slattered or uneven bobbins, or want of twist in roving, too big a draft in Mule rollers, too much gain and drag, knocking out too tightly, etc. There are quite a number of extra motions about a modern spinning Mule, especially if it is intended for fine counts. The temperature and humidity of the spinning require to be nicely adjusted if the best spinning is to be got from the cotton used. About the best temperature for a Mule room spinning American cotton is 78°, with the wet bulb standing at 66°. This is equal to six grains of water to a cubic foot of air. The high temperature softens the waxy coating of the fibres, which, when in a cold state, are hard and congealed, interfering with good spinning. All new mills are fitted with humidifying and ventilating appliances. Not only do these appliances humidify the air, but they purify it from soot, thus keeping the cops clean. They also improve the health conditions of the workpeople.

In spinning the finer and better qualities of yarn there are several extra processes. The sliver in this case would be taken from the card, passed through one passage of the Draw Frames, to level the sliver up somewhat. The slivers are next taken to a sliver lap



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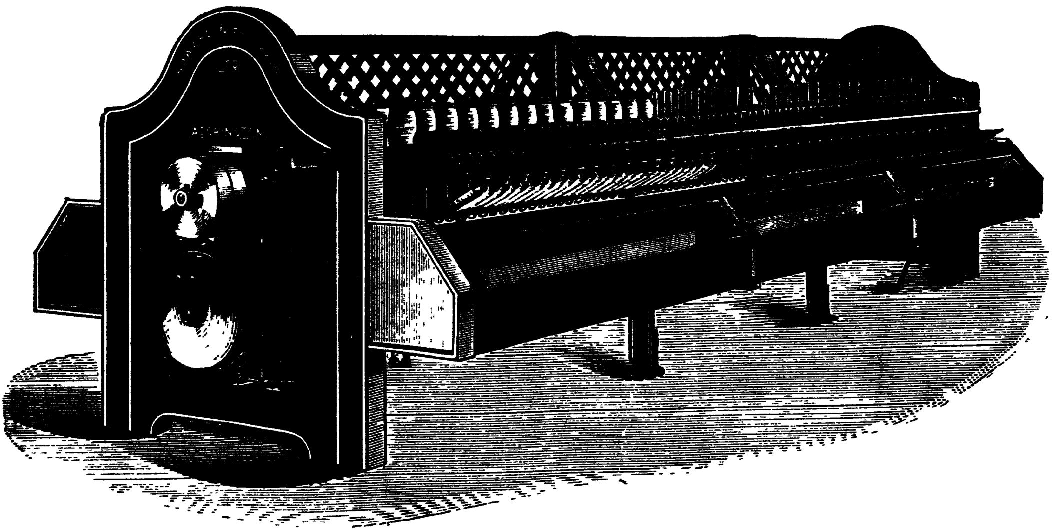
MULE SPINNING ROOM—ELECTRIC POWER

machine, which doubles a number of the slivers together and makes a lap about $10\frac{1}{2}$ inches wide. The laps are taken to a ribbon lap machine, which draws them, then doubles them at the front of the machine, and makes a lap ready for the combs. The object of both these machines is to make a lap uniform and homogeneous yard per yard, so that the comber can perform its duties better. These ribbon laps are taken to the comber, which remove all fibres below a certain length, and cleans the cotton from the very fine impurities which cannot be got out in carding.

It is now becoming the practice to comb card strips. The old style of comber could only satisfactorily comb long fibre, but of recent years combers suitable for combing short-stapled cottons have been invented. These combers have encouraged many people to comb their card cylinder and flat strips, with very satisfactory results.



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WINDING FRAME

CHAPTER IV

WINDING, WARPING, AND WEAVING

THE cotton manufacturing industry of this kingdom, producing plain and artistic cloths in many varieties for all the Home Markets and Distributing Centres abroad, constitutes one of the great factors in our industrial and commercial greatness. Were we to seek for evidences of wonderful natural gifts and great genius, we can find them in an eminent degree in the evolution of the productive arts. One has only to compare the perfection of the system of cloth production in the present day with the primitive forms of olden times, to realise how wonderfully mind has conquered matter, and how cleverly it has brought scientific exactitude and artistic merit to bear in all the minutiae of textile work. The Weaving Districts of England are principally centred in North and North-east Lancashire, where the humid climate is an advantage of inestimable value to cloth production. There is also weaving in the Bolton, Manchester, Ashton-under-Lyne, Stockport and other South Lancashire Districts, principally attached in the latter places to the spinning mills. In towns like Preston, Blackburn and Darwen, too, many firms both spin and manufacture. In Yorkshire there is cotton weaving in the district of Todmorden; and in the Scotch counties of Ayr, Renfrew, and Lanark weaving has in recent years increased in substantial measure. From the domestic production of spinning and weaving, there emerged the factory system. In describing the process of cotton manufacture we begin

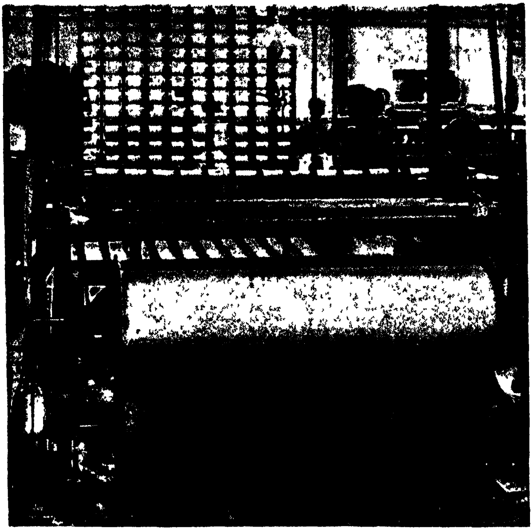
with the yarn as purchased from the cotton spinner and delivered at the weaving sheds.

The manufacturing processes, pursued in the weaving sheds, consist (1) of winding from the cop to the bobbin, (2) of warping or beaming, (3) of sizing, (4) of looming, and (5) of weaving. The yarn, as it comes from the spinning mills, is of two distinct series of threads—twist and weft. The twist forms the thread which runs from end to end of the cloth, and is called the warp. The weft threads, called "picks" of weft, traverse from side to side to the selvedges (self edges) of the cloth, and are sometimes called "woof" or "filling." Twist yarn having to bear a greater strain in the course of manufacturing, is stronger than the weft. The first process, after spinning, is that of winding. The object of this is to place a suitable length of yarn on the spool or bobbin. This bobbin is usually made of wood about one inch in diameter with a flange at each end of about 4 inches diameter, the distance between the flanges being about 4½ inches. The weight of yarn which can be placed on one of these bobbins is approximately three-quarters of a pound. In yarn of average or medium thickness, the length would be about 27,000 yards. The operation of winding is simple, and has little or no effect upon the material which is being used. The work of the winder is light and is quickly learned by girls or women, who earn on the average about 16s. a week. The usual cop winding machine will have about 360 spindles with one bobbin upon each spindle and about 30 of these spindles constitute the work of one winder. The work of the winder consists in replenishing the yarn and piecing up broken threads. It is essential that in piecing the thread the knot should be neatly made and the ends broken off short. A very ingenious apparatus, called the Barber Knotter,

has been devised by an American inventor. This is a small machine strapped on to the hand of the winder. The broken threads are placed in position for the repair; a lever is moved by the thumb and the knot is instantly made and the ends clipped quite close. It is claimed that this enables the operative to attend to more spindles, and that the knot is neater and better made, which is a great advantage in the subsequent processes.

Warping

The second process is warping or beaming, and here we have three distinct methods which are made use of according to the kind of cloth which the manufacturer is about to make. The methods are termed Beam, Mill, and Section Warping. In beam warping a number of the bobbins which have been filled on the winding frame are placed in a creel or frame, the usual number ranging from 500 to 600. The threads from the bobbins are taken separately, passed through the machine and made fast to the warper's beam. This beam is of solid wood about 5 inches in diameter and 60 inches long with an iron flange upon each end of a diameter of 21 inches, or thereabouts. This beam rests upon a revolving cylinder of wood which imparts the motive power to the beam, and gradually draws round it the threads from the bobbins. The amount of yarn which one of these beams will hold is about 300 lb. and a common length in medium counts would be 500 threads each 20,000 yards long. The principal device in this machine is the automatic stop motion, bringing the machine to a stand the instant a thread breaks. The operation is simple. A piece of bent wire about 2 inches long in the form of the letter " U " inverted hangs upon each thread. This is technically termed the drop pin. Should the



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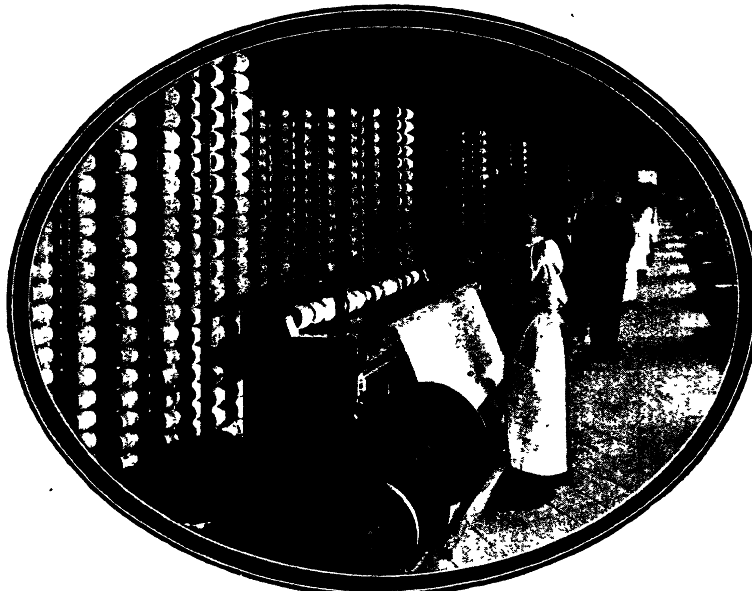
WINDING YARN OFF BOBBINS ON TO WARPER'S BEAMS

thread break upon which the wire is suspended it falls down and is caught between two revolving rollers which are in close contact with each other. As the wire passes between these rollers it necessarily presses them an infinitesimal distance apart; but this distance though exceedingly small is sufficient to relieve a delicately adjusted lever which brings the machine to a stop immediately. The work of warping is genial employment for women; the wages earned are fairly good, amounting to about 22s. per week on the average. Usually the winders are promoted to the work of warping.

In mill warping the bobbins are also placed in a frame or creel, but the number is limited to about 200. The threads are then gathered separately from the bobbins and formed into a rope. This rope is made fast to a peg upon a large upright wooden cylinder or reel. The sizes of these cylinders or reels vary considerably but a common size would be one of 8 to 10 feet high, and 12 yards in circumference. This large cylinder is made to revolve in either direction, backwards or forwards, as required. After the rope of threads has been made fast to it the movement of the cylinder commences and as it revolves, the rope by suitable mechanism, is made to traverse from the bottom of the cylinder to the top, thus avoiding the whole of the yarn being run in one place on the cylinder. After the rope has got to the top of the machine, the direction in which the cylinder is running can, if required, be reversed and the rope begins to descend. By this means any suitable number of threads and length may be warped. For example, if a warp was required 360 threads, 500 yards long, 180 bobbins would be put into the creel, and 500 yards would be run on to the cylinder. Then the motion would be reversed, and similar ends and length would



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WINDING YARN OFF BOBBINS FOR WARP

be run on to the top of the first, thus completing the warp required. This rope, or warp, as it is called, is then drawn from the machine and made into a ball for delivery to the dyer and sizer.

In the section warper the yarn used is such as has been previously sized, or yarn which does not require to be sized. These processes of sizing will be explained later. Here, again, bobbins are placed in a creel, and are drawn off on to a *cheese*. This cheese is a block of wood a few inches in diameter and length, and practically forms a miniature of the beam, explained in beam warping, but without the flanges. After a suitable length has been placed upon this cheese others of a similar character are formed. The whole of the cheeses are then placed upon a shaft and run off on to the weaver's beam. A cheese, therefore, really forms a transverse section of the weaver's beam. Where beam warping is used the cloth is usually made in the "grey" state, that is, it does not contain threads which have been dyed. If the manufacturer is one who makes coloured goods or cloth composed of coloured threads the mill, or section warping, will be the one which he will adopt. Manufacturers differ in their opinion as to the relative value of mill and section warping.

Sizing

The process following warping is that of sizing, which consists in applying a paste to the yarn in order to strengthen it and enable it to withstand the friction to which it is subjected in the loom, where there is considerable tension on the threads. For certain classes of goods sizing has additional uses, first to add weight to the cloth and, secondly, to give the cloth a "feel" or "handle" which enhances its market value. The necessity of sizing was realised in the old hand-loom

days when it was done in primitive fashion. The art of perfect sizing is obviously one of supreme importance. All twist which is single must necessarily be sized, but folded yarn will weave without size. A folded yarn is one in which two or more single threads are twisted together rope-like, the threads strengthening each other. This is the kind of yarn referred to in section warping, where it was stated that this peculiar process of warping was suitable for yarn which did not require sizing. The paste, or size, which is applied to the yarn, is in its simplest form made from some farinaceous substance such as wheaten flour, farina or potato starch, or sago flour. This is boiled in water, and a small quantity of tallow added to it, which keeps the yarn pliable. Japanese wax and paraffin wax are used as softeners in the light sizings, and castor oil and glycerine are at times used. The amount of size used varies according to the kind of cloth to be made. It may be as low as 5 or as high as 200 per cent. Those cloths holding above 50 per cent. of size are known as heavily sized, and those below that percentage vary from light sized up to about 20 per cent. and medium sized up to 50 per cent.

For cloths which require weight adding to them other materials are used, such as China clay, chloride of magnesium, muriate of zinc, etc., the latter being a great antiseptic and strong preventive of mildew. The prevention of mildew is of vital importance to the manufacturer, for if the vegetable growth is found to have developed, owing to sizing defects, after the cloth has reached the distributing centres, the loss falls on the maker. Size is mixed in strong wooden becks, equipped with revolving dashers, or agitators, which keep the mixture stirred up and ensures the blending of the various ingredients. The usual number of becks or tanks is four, each with pump attachment,

to send the size mixing, which has to be thoroughly boiled and with no granulation, on to the size box on the slasher frame.

The slasher may be divided into three portions, all coupled together, first, the sizing; secondly, the drying; and thirdly, the winding. Sometimes the process is called "taping," a term which was used in the days of the tape frame well on for half a century ago. A piece of cloth usually consists of several thousand threads, and in order to form these, a number of warper's beams of about 500 ends each are placed behind the sizing machine. The threads from each beam are then gathered together in one compact sheet and run under a roller which is immersed in the boiling size, which impregnates every inch of the fibre which passes into it. Mr. C. P. Brooks admirably illustrates this in his book on *Cotton Manufacturing*.

> "Supposing a warp is required of 2,480 ends—three beams, each 504, will be taken together with two of 484 each; these are placed in the creel in two levels, and the narrower ones are placed at the back. If they were in front of the broader ones the sheet of warp would overhang the narrow beams. The ends are gathered in one sheet, the layers from the hinder beams passing over the top beams and under the bottom ones, all leaving the creel after passing under the foremost beam and travelling into the sow box. Two contiguous boxes or troughs are used for holding the size—the one farther from the creel, called the size box, receiving the mixture directly from the beck, a regulating valve being fixed on the inlet pipe to prevent the box becoming too full. The sow box is the larger one, and receives the size from an aperture in the bottom of the size box, as

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A SIZING ROOM

well as from a separate pipe. In the bottom of the sow box is fixed a boiling pipe of elliptical form, perforated with small holes, through which steam is forced into the size, causing it to boil, and thus always be in the fittest state for application to the yarn. At about half the height of the box two pairs of rollers are fixed, the back pair having the bottom one of wood, and the top one of iron, covered with flannel and cloth ; the front bottom roller, or finisher, is of copper, having resting on it a heavy iron one, likewise covered with several layers of flannel and two of cotton cloth. On the firm and even surface of these rollers depends to a great extent, the quality of the sizing. Between the wooden roller and the end of the box nearest the creel is a copper immersion roller, its use being to lower or raise the warp in the size by means of a rack and pinion. The warp ends coming up from the beams pass under the immersion roller, thus being soaked under the surface of the boiling size, thence between the first and second pairs of rollers—the object of these being to press out all superfluous size and imbed into the thread that which is required. Immersing the thread deeply is advantageous for heavy sizing, although, by simply dipping it, the fluid only attaches itself to the outside of the thread. Better results could be obtained by pressing the yarn whilst under the surface. Unless well boiled, size retains a granular nature, causing faulty cloth ; to obviate this, many machinists insert between the size beck and the sizing frame an extra boiling apparatus so arranged by the intervention of pipes to boil the size under pressure, impinging steam against the particles of size as they enter the box, thus breaking the globules. After boiling thus, the size enters the box in the ordinary way. To

lay the fibres on the yarn a few sizers have recourse to revolving brushes acting on the thread directly after passing the finisher roller. These revolve about 700 revolutions per minute, considerably faster than the warp speed. They are considered advisable for fine reeds and fancy goods."

After leaving the rollers the yarn passes over two steam-heated revolving cylinders, of about 7 feet and 4 feet diameter respectively, and is then wound on to the weaver's beam, in front of the machine. This process of sizing is applied to yarn made on the beam warper. To indicate the weaving lengths the warp is marked by the measuring roller on the sizing frame.

As stated in mill warping, the warp in that process is gathered up into a ball. This ball form is simply for the convenience of handling. The ball is taken to the sizer, is unwound, and the rope of yarn is passed through the boiling size, and is afterwards dried on hot cylinders, the threads spread out and run on to the weaver's beam. The differences between the two systems of sizing are known as tape-sizing and ball-sizing. The work of sizing is done by men who are well organised as a trade. They are in receipt of good wages, usually about two guineas or more per week.

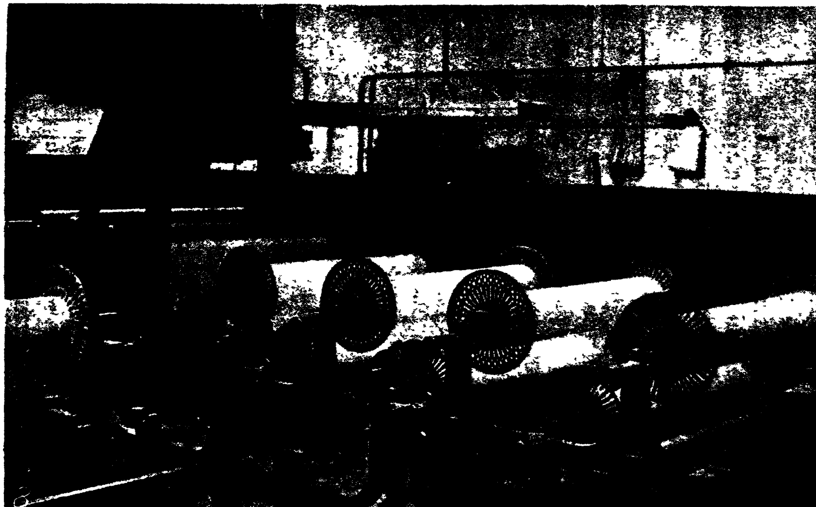
Looming and Drawing

The beams holding sized warp, varying from 500 to 1,000 yards in length, are now taken into the Looming Loom, where the threads of the beam are attached to the healds and reed. The healds are for the purpose of raising the threads as required in the loom to form the pattern of the cloth. The reed may be described as a kind of grate or grid, the bars being made of extremely fine wire placed at suitable distances

apart in strips of wood, by the aid of machinery. The reed has a three-fold purpose—first, to give support for the shuttle as it passes from side to side of the loom; secondly, to keep the threads of the warp in their proper place in the cloth, and thirdly, to bring up each succeeding line of weft in close contact with the one which preceded it. The loomers and drawers who attach the beams to the healds receive about 30s. per week, and the work is of a light character.

Weaving

We have now reached the final stage by which the cotton is converted into a woven fabric—that of weaving. It will be seen how the textile processes are conducted in sequence, with the greatest expedition and economy of labour. The machinery in the various departments is driven by the powerful modern engine. It may be taken that a condensing horizontal engine of 250 indicated horse-power will be required to drive 1,000 looms, the steam being generated in double-flued steel boilers where it not uncommonly attains a pressure of 120 lb. per square inch. The huge development of cotton manufacturing has been one of the industrial phenomena of the past 100 years. It was in 1801 that the first power loom weaving shed, holding about 200 looms, was built and worked on a successful basis. The great strength of British weaving, as pointed out, resides in North and North-east Lancashire. Here the majority of the sheds are owned by private firms, but a few are owned by companies formed under the Limited Liability Act, which was passed in 1862, and enabled working people to invest their money, with a limit to their liability. The plain loom is the foundation of all weaving; the fancies, etc., being developments in mechanism, some of an intricate character. Art has



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SIZING

become more and more the handmaiden of industry, as will be seen in the references to education in a later portion of this work. The width of cloth varies from about 20 inches to 100 inches, though even this is sometimes exceeded, the average width being about 42 inches. We have seen with the completion of the sizing how all is ready for the culminating process. The beam with the healds and reed is taken to the loom, the various parts being fixed in position on the framework. The warp (which is held taut and straight by the taking-up roller in front of the loom) passes over the back rest to the healds, between which are large and small lease rods, which divide the warp. The weft is skewered in the shuttle, driven by the picking stick from side to side and interwoven with the warp, cloth being rapidly made. The various forms of looms, and the appliances for making different patterns and qualities of cloth are innumerable, and would occupy of itself many volumes to adequately describe. Briefly put, weaving consists of three operations—first, to divide the warp by lifting up certain threads and leaving others down to form the desired interlacing of the warp and weft; secondly, to throw the shuttle between these two sets of threads, leaving a line of weft in its track; and thirdly, to bring this line of weft up to the one which has preceded it. These operations are technically termed "shedding," "picking," and "beating up." "Shedding" is done by three distinct sets of appliances termed tappets, Dobbies, and Jacquards, which are limited to the formation of simple, medium and difficult designs. These are again subdivided into many kinds of each sort; each with its own peculiar advantage to some special make of cloth. Reference has been made to the growth of artistic treatment of cotton cloths. To give some idea of the various kinds of tappets

there are, among others, positive, negative, wood-croft, oscillating, etc. Some work outside the loom, some inside and some overhead. In Dobbies there are single-lifts, double-lifts, open shed, centre-shed, and many more. In Jacquards there are single and double lifts, some described as single cylinder, others as double cylinder, all having their various peculiarities, advantages and disadvantages, where so many kinds of cloth are to be made. There are many kinds of picking motions, such as under-pick, over-pick, scroll-pick, each again particularly useful for different fabrics; but all serving the same purpose, namely, to throw the shuttle from side to side of the loom. The over-pick is the commonest. The shuttle is usually made from cornel or persimmon wood. It is about 13 inches in length with iron tips at each end. Inside the shuttle is an iron peg on which the cop is corkscrewed and the thread is drawn by the weaver by suction, through the eye of the shuttle.

The beating up is invariably formed in one way in all looms; that is, to carry the reed forward, with the line of weft in front of it, up to the edge of the cloth, which is being woven. The reed then recedes for some 5 inches for another pick of weft, which is beaten up, and so the weaving proceeds. The loom has also other minor appliances. There is one, for instance, for stopping the loom when the weft-thread breaks, or the supply of weft runs out of the shuttle. Another portion of the mechanism is for carrying the cloth forward on to a roller as it is woven. A third enables different kinds of weft to be automatically inserted in the cloth by means of shuttles (each of which contains a different kind of weft) being thrown across the loom in any required order.

The weaving shed is a most interesting sight, often

containing 1,000 looms, the rattle of the machinery being almost indescribable to a visitor, yet to the busy operative it is hardly realised. The shuttle in each loom often passes across the sley 200 times a minute, and a single loom will often weave 200 yards of cloth in one week. This, of course, varies considerably according to the kind of cloth which is being made. The art of weaving is one which requires considerable skill, the wages earned varying from 10s. to 30s. per week, according to the number of looms which the operative controls, and the class of goods which are being produced. The number of looms operated by one weaver varies from two to six, the average being three to four. The shed and the preparing departments are directed by a manager, who is a thoroughly experienced man, with great technical knowledge, and an economical administrator, who has to keep strict eye on the details of expenditure. The weavers are controlled by an overlooker, who is responsible for the work which is turned out by a section of the looms varying from 60 to 100, according to the class of cloth which is being made. The overlooker, or tackler, sees to loom repairs, to the looms being supplied with warps, correctly gaited, etc., and he has an interest in doing all he can to keep up the production and therefore also the earnings of the weavers.

As will be shown later, the plain and fancy cloths made in such infinite varieties are distributed throughout the world, our two greatest markets being India and China. The spread of the cotton trade throughout the world is most remarkable. For a long time Lancashire was practically the sole producer of cotton cloth, but now the manufacturing system is rapidly becoming adopted by all civilised countries. The competition, too, is extremely keen, and the utmost vigilance is

required if the manufacturer is to secure an adequate profit upon the capital invested.

The actual fabrics themselves are divided into five classes: plain, twill, figured, gauze, and double cloths. The ordinary calico is an example of PLAIN cloth. TWILLS are those where regularly defined lines run obliquely across the piece. FIGURING is applied to cloth with more or less elaborate designs, from the common spot to a large floral effect. GAUZE fabrics are cloths where the warp threads are made to cross each other instead of running straight. A common form of DOUBLE CLOTH is the woven bag, or pillow-case. Another class may be referred to, though it is really one of the foregoing. It is that of pile cloths, of which velvet is the common form. But in addition to all this, these various classes are subdivided into almost innumerable varieties of each class. Take, for instance, that of plain cloth. Amongst the varieties are shirtings, printers, jaconettes, long cloths, dhooties, madapollams, royal ribbs, poplins, etc.; all these being of a perfectly plain weave but differing in texture and appearance, and adapted for the peculiar requirements of people all over the world. India and China are the large markets for shirtings, but the Chinaman, as a rule, requires a better article than that which will find a purchaser in the Indian market. Dhooties are goods confined solely to the Indian trade. A plain dhooty is a plain calico with coloured edges varying from $\frac{1}{8}$ inch to 3 inches in width, and at regular distances of from 2 to 5 yards coloured bars of weft of a more or less elaborate character pass across the piece. These dhooties form an important article of clothing in India, the coloured portion being considered a phase of ornament. Borders are sometimes also worked up into more or less elaborate figures and they then pass from

the plain section to the figured class, necessitating the use of other appliances to the loom, such as the Dobby and Jacquard.

The texture of different classes of dhooties also varies to a very great extent. In some the yarn is of a very coarse kind and is heavily weighted with size ; in others the yarn is of the finest character, the difference between the two cloths, although for the same market, being very remarkable. Probably the requirements of the various classes, from the very poor to the better circumstanced, is the reason accounting for this. In some cases, the coloured borders, in addition to being elaborate in the way of figuring, are formed of coloured silk threads instead of cotton, thus increasing the value of the piece to a great extent. As nations become more civilised the requirements change from that of a common character to one embodying more or less elaborate detail and better finished articles, and to China and Japan there are now shipped large quantities of the very best class of figured goods. From the near Eastern markets quite different classes of fabrics find sale. We find crimps and crepons in large demand. These are goods which have a crimped or creased appearance on the surface. For the home trade the best qualities of plain goods as well as the more finished fabrics are in demand, and during recent years the production and sale of flannelettes has greatly increased. These various classes of fabrics are in some instances almost confined in their manufacture to certain districts being in a sense their specialities; but as the spread of education and competition goes on the distribution is more widely spread, manufacturers being gradually forced into producing other classes of articles than those to which they have been accustomed.

Blackburn is probably the largest centre for the

making of shirtings, enormous quantities of these goods being turned out daily. A large section of the dhooty trade is also located in the same town, though one or two of the smaller places, such as Darwen and Great Harwood, seem principally adapted for this particular kind of fabric. In the Rossendale Valley the principal manufacture is of coarse goods which are very heavily sized. In Preston and the immediate neighbourhood the goods manufactured are generally of a most elaborate kind, though in the town itself there is probably the first firm of shirting makers in the world. In Bolton district the classes of goods made are chiefly fine cambrics, a great many quiltings, coloured counterpanes, etc.

In the making of velvets a large proportion of the weft threads are allowed to form to some extent loosely upon the surface of the cloth. Under these weft threads a fine knife is run, severing them, and causing the ends to stand upright which gives the peculiar surface which is associated with the velvet cloth. A large use is now being made of cotton to imitate woollen products. One of these is commonly known as flannelette. This is an ordinary cotton fabric made from coarse yarns. After being woven it is passed through a machine which combs up, or teases, the fibre on the surface giving it the peculiarly fluffy or woolly appearance which is so well known. The heavy pile cloths include corduroy, moleskins, cords, fustians, bull-hides, etc.

From the Weaving Shed the weaver takes her " cuts " or pieces of cloth to the warehouse, where they are received by the cut-booker, and her wages are made up from the list prices. The cloth is put on the folding machine which plaits it into yard folds. The cuts then go (marked with the loom number of the weaver) to the

cut-lookers, who stand at their benches and rapidly examine the cloth to discover any imperfections. For cloth faults due to the weaver, such as " floats " caused by failure to interweave at some point, the weaver is " bated " or fined according to the seriousness of the fault. Cracks in the cloth, uneven cloth, cockly cloth, bare cloth, mashes, broken picks, etc., are all noted, as well as any short lengths, wrong widths, wrong weights, incorrect headings, and come within the observing and classifying duties of the cloth-looker. The cloth headings consist of lines or bars of coloured weft at each end of the cloth or in other places. They are to distinguish the piece and to indicate where the pieces are to be separated. Some of these headings are very deep and attractive, with lines of gold thread and coloured weft.

In the cloth warehouse the cloth is made up into bundles. Some are sent directly to the shipper, others go to the Manchester warehouses, where they are again examined, whilst others go direct to the bleachers.

TECHNICAL EDUCATION

The great advancement in technical education has made, and will probably still further increase, the production of cloths of an artistic character. In the technical schools of Lancashire and other counties, in which cotton spinning and manufacturing is conducted, the textile classes are attended by large numbers of students, some of whom have obtained important managerial positions. There are thousands of students from the operatives' ranks who can bear testimony to the great advantages they have gained through the courses of instruction given in these institutions. Examinations are periodically held, and the prizes on a very liberal and attractive scale are given by Local

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WEAVING

Authorities, County Councils, the City and Guilds of London Institute, the Worshipful Company of Drapers, and other bodies. The instruction given is not merely theoretical. The latest machinery is set up in some of the institutes and the whole details of both the spinning and manufacturing processes are made manifest.

Automatic Looms

The intense competition in trade has had the effect of stimulating invention, of patenting appliances for making peculiar classes of goods, and for increasing the production of machinery. One of the most important of the latter kind is the Northrop loom, an English invention, bought by an American firm, which is largely in use in the United States and has been introduced into Lancashire. Seeing that the automatic principle will more and more come into use in the future, it will be of value and interest to look into a Rhode Island mill and see the loom at work. There are marked differences in the systems and organisations of English and American mills. A visit was made to the cotton spinning and weaving districts of America by a body of English manufacturers in 1902; they found the Americans were making greater headway than we in England in the economy of production. They found also that there had within the past quarter of a century been phenomenal developments in manufacturing in the Southern States, and that there was now a marked growth of their competitive power. In some of the sheds in the Southern States it was found that quite young children were largely engaged, which meant of course a large reduction in the wages bill as compared with the North. The goods in which this labour was chiefly employed upon was in sheetings, jeans, and drills for the distributing centres in China, and it was

obvious that the odds operated as heavily against the New England mills as they did against those of England. The American Trade Unions, however, are growing in strength and the tendency is yearly in the direction of equitable wages adjustment. It was found by the Lancashire commission that the American spinning mills did not get a great advantage over us, in the cost of carriage for the raw material. As a matter of fact, Mr. T. M. Young, who accompanied the English deputation and who wrote the results in a series of articles reproduced under the title, *The American Cotton Industry*, found that the cost of bringing raw cotton to the mills of New England was practically the same as that of conveying it to the Lancashire spinner. In South America some advantage is gained, but it is inconsiderable. The great difference between British and American manufacturing systems is the extensive use in the States of the automatic loom, affecting a marked reduction in the cost of production, yet materially advancing the wages of the weaver. These looms were adopted by Germany, France, Belgium, and Austria before they were introduced into Lancashire.

It was at a mill close to Fall River and within the State of Rhode Island that Mr. Young found 2,000 Northrop looms and 743 other looms all 32 inches wide or more, making twills and sateens largely from 28's to 36's weft, spun from " strict good middling " cotton of 1 inch to 1⅛ inch staple. These looms were fed by 17,300 mule spindles and 60,000 ring spindles and the mill was driven by a steam engine of 2,000 indicated horse-power, the annual consumption of coal being about 8,000 tons, and the cost of coal was then about 13s. 6d. per ton. Seeing that this automatic loom is coming into great use, a description of it will be valuable. Mr. Young says—

"The essential difference between it and the common or any other automatic loom is that when the weft breaks or is exhausted, the shuttle is automatically recharged with weft, and threaded without being itself removed from the sley. There is a cylindrical battery or magazine, like a magazine of a revolver, over the shuttle box at the side of the loom, and this magazine can be filled with 'cartridges'—either bobbins of ring weft or cops of mule weft. Ring weft for the Northrop loom is spun on specially made bobbins, which are simply laid into the magazines; cops have to be skewered upon a steel spindle, with a wooden head similar to that of the ring bobbin. When the weft-changing mechanism is brought into play by the action of the weft-fork, a bobbin, or a cop on its skewer, is forced from the magazine into the shuttle, which is always then at the end of the sley immediately beneath the magazine; the spent bobbin, or skewered cop, is forced out through the shuttle and the bottom of the sley, and with the first impulse of the picking-stick, the shuttle threads itself and the weaving continues without interruption. All that the weaver has to do, then, in regard to the weft, is to keep the magazine charged with weft, and as there is always a contrivance in these looms which stops them when a warp thread breaks, the weaver has no need to watch the warps; when he sees the loom standing, he goes and finds the broken end and ties it up and starts the loom again—that is all. The weft magazine may contain as many as thirty charges, enough to keep the loom running for a couple of hours. The Northrop loom is the invention of an Englishman, James Northrop, formerly of Keighley; but the Draper Company, of Hopedale, Massachusetts, who bought the patents have spent

very large sums of money in perfecting the machine and adapting it to the varying exigencies of industrial use."

It is clear this loom will have to be largely adopted in Lancashire before long.

There are two things which have probably hindered the adoption of the Northrop loom in this country. First, its price, which is about four times that of our ordinary loom, and secondly, the natural resistance on the part of the operatives, who have now been organised for many years. Still, it is slowly and surely making progress and will continue to be gradually installed as the ordinary looms are worn out. Near Manchester there is at the present time a shed holding 1,000 looms, all properly laid out and equipped.

CHAPTER V

BLEACHING, PRINTING, AND DYEING

THE printing and dyeing of cotton fabrics is something more than a mere mechanical operation. The development of this branch of industry is due to the skill of the cleverest chemists, foremost amongst these being John Mercer, the inventor of the mercerising process by which cotton cloth is made to resemble silk, and the late Frederick Steiner, a famous French chemist, who introduced a turkey-red dye, famous all over the world.

Before it can be dyed or printed upon, all cotton fabric must be bleached, to rid it of all impurities or everything present in the fibre except cellulose—or, in other words, a small quantity of margaric acid, pectic acid, albuminous matter, and colouring substance. In woven goods the artificial impurities may amount to 20 or 30 per cent. They consist of grease, starch and other ingredients used in sizing, besides oil from the machinery. The removal of these impurities in order that nothing but pure white vegetable fibre may remain is the result sought with the highest grade of bleaching —technically known as the " madder bleach "—because it was first applied to goods to be printed with madder, a substance much used in dyeing red. It is also used for cloths which are to receive light and fine colours.

Previous to the bleaching operation proper, the pieces are singed, in order that the fine loose down may be burned off the surface of the cloth, as this down interferes with the production of a fine impression in the printing process. This operation is performed by rapidly passing cloth in the open width over red-hot copper plates or

between rows of Bunsen burners, while the cloth is drawn rapidly over one or more of these hot plates by means of rollers; a frame with iron bars depresses the cloth tightly upon the hot plate. After passing over the singeing plate or between the gas burners, the cloth is immediately passed through a water trough, or through a pair of wet draw bowls in order that any sparks may at once be extinguished. The pieces are drawn direct from the singeing house, guided by means of glazed earthenware rings through the washing machine and plaited down " in pile " on a stillage in the bleach house, where they are allowed to lie a few hours to soften. The second process in bleaching consists in boiling the cloth in milk of lime and is a very important one. As already stated, the cotton fibre is made up of cellulose and a small quantity of other substances. The object of the lime boil, therefore, is to break up the combination of the wax and cellulose. The selection of lime is also a very important matter, as if the lime be old it will have absorbed carbonic acid from the atmosphere, and this will render it unfit for bleaching purposes. Having been boiled in lime for about twelve hours, the cloth is passed on into the kier. The cloth must be packed in the kier very systematically, this being done by boys, who go into the kiers when they are being filled, and with their hands and wooden clogs on their feet carefully tread down the cloth in such a way that it will not get tangled in the boiling process. After the goods have been properly boiled the waste liquor is run off from the bottom of the kier and the cloth is drawn by the draw bowls of the washing machine from the kier. At the same time much of the lime and dirt is removed from the cloth during its passage through the washing machine, but as only a portion of the lime can be removed in this way, the cloth is next subjected to a

treatment with weak hydrochloric or sulphuric acid. The next operation is boiling the cloth with caustic soda. After the cloth has received another washing and passed through a weak solution of chloride of lime and dilute hydrochloric or sulphuric acid, it is ready for being printed upon.

Until the invention of machinery, the operation of printing was performed entirely by hand. The design was applied by means of blocks of some hard, fine-grained wood, such as pear or sycamore. Upon the face of the block the design is carved much in the same manner as a wood engraving. Sometimes the pattern is formed by slips of flattened copper wire inserted along its outlines, which are first traced upon the wood. The copper slips are carefully bent to the required shape and are then forced into the positions they are to occupy by gentle hammering. The upper edges where the copper stands above the wood are levelled with a file, in order to form one even surface, and polished. The spaces between these slips are filled up within the boundaries of the design with pieces of thin felt. In hand-block printing, the piece to be operated upon is spread out evenly upon the printing table, which is covered with blanketing. Close to the printer stands a tube containing the colour. A wooden drum, like the wood work of a sieve, is covered with waterproof tissue, over which is stretched a fine woollen cloth, upon which the colour is spread. This drum is placed so as to float on the tubful of old paste.

The colour is spread on the drum-head. Then the printer applies the face of the block to the drum-head, then lays it carefully upon the cloth and strikes it on the back with a hammer or presses heavily upon it, so as to force the colour into the cloth. The great drawback to this method of printing is the expenditure

of time and labour involved. To print a piece of calico of the ordinary length, 28 yards by 2 feet 6 inches, with the ordinary size blocks requires about 672 carefully managed applications. If there are four or five colours the number of applications are from 2,600 to 3,300. To a very large extent, therefore, block printing has been superseded by machine printing. The machines now in use can print designs embodying as many as twenty different colours, and the largest machines can turn out anything up to 500 yards of cloth per hour. The design is first engraved on copper rollers. If there are several colours to be printed, each colour has to have a separate roller, and it is the duty of the man in charge of the machine to see that all the designs are so fitted that they will form a perfect whole. The machine consists of a large iron bowl, or drum, against which are pressed the engraved copper cylinders, the colour being supplied to the cylinders by wooden rollers covered with cloth, or sometimes by cylindrical brushes, called "furnishers." The furnishers revolve in the colour, which is contained in long troughs called "colour boxes." But as the furnishers supply the whole surface of the engraved cylinders with colour, as well as the engraved parts, the surface colour has to be scraped off again, and this is done by means of a steel blade, known as the "colour doctor." The cloth to be printed passes part way round the bowl of the machine and between the engraved rollers and the bowl, when it receives the colour. In order to remove any lose threads or filaments from the roller, a "lint doctor" is used, working on the opposite side of the engraved roller to which the colour doctor is applied. The doctors are made of well-tempered steel, and they have to be exceptionally sharp in order to effectually remove the surplus colour without doing injury to the engraved copper roller. The machine printer has many

difficult duties to perform. Besides tuning up the doctor and keeping the pattern rollers in register or fit, he must carefully adjust the amount of pressure, so as to bring out the print and yet not press the colour too far through the cloth.

After being printed, the next operation is drying, this being of great importance. The methods of drying vary. In some cases, copper or tinned iron cylinders, heated by steam, are used for the purpose and in others flat hollow cast-iron boxes, called steam chests, over which the cloth passes without quite touching. It is necessary to state, however, that after bleaching and before printing the cloth is prepared with oleine oil.

In the preparation of colour each works has a staff of chemists who are constantly experimenting with a view to securing more brilliant or faster colours. The majority of colours are derived from coal-tar. The two mordants, red and black liquor, are very largely used by calico printers in what is called the dyed or madder style, one of the oldest and most important of the various styles of calico printing. In this style the thickened mordants are first printed on, then dried, aged, dunged, and dyed with alizarine, or other acid colouring matter. Before they can be printed, mordants have first to be made into what are technically called " colours." In other words, they have to be made into a kind of paste by means of some thickening matter, as starch, gum, etc. These colours are not necessarily coloured substances, though they do usually contain some kind of colouring. This, however, is only for the purpose of sightening, so that the printer may be able to see his work on the cloth. This sightening is afterwards washed out of the cloth. Prior to being dyed, the cloth must pass through the ageing and dunging, or fixing, processes. The object of the former is to decompose the acetates, so that the

acetic acid is driven off, leaving the insoluble bases on the fibre. Steam machines are used for this process. After passing through the machine, the cloth is folded up in loose bundles and left for twenty-four hours. The decomposition of the mordants, which was started by the action of the steam in the ageing machine, goes on slowly whilst the cloth lies in the bundles. As this ageing does not effect a complete precipitation of a suitable mordant on the fibre, it must be followed by the fixing process. Then follows the dyeing. After dyeing, the cloth is well washed in cold water, and afterwards dried. In the extract style of printing, the mordants and colouring matters are mixed together and printed on the cloth in one operation, after which they are steamed. With the extensive use of the many-colour printing machines, the extract style has become more prominent, and it gives far more beautiful effects of colouring. Colours for the extract style are printed on cloth previously prepared with oleine oil. By this means faster and brighter shades are produced.

The shades of colour in which the cotton fibre is dyed and printed are almost innumerable, but they are almost all made up of red, yellow, blue, black, and white substances. To obtain the shades, the various colours have to be boiled, but it does not follow that all shades are boiled. If a very dark shade is prepared it is a very easy matter to obtain a lighter shade by reducing it. This, in brief, is an outline of the bleaching, printing, and dyeing processes.

CHAPTER VI

MARKET DISTRIBUTION OF YARN AND CLOTH

WHILST Liverpool is the great market for cotton, a considerable quantity of the raw material comes direct to Manchester, via the new Ship Canal, the cost of transit being much cheaper for the cotton mills in the Manchester district. The great central emporium for the sale of both yarn and cloth is the Manchester Exchange. Manchester is the Mecca of all connected with the English cotton manufacturing business. At the end of the eighteenth century the master attended the weekly market at Manchester and sold his pieces in the grey to the merchant, who afterwards dyed and finished them. At times goods were sold outright to the calico printers. Deliveries of prints would be made at the Manchester warehouse from the print works on Tuesdays, Thursdays, and Saturdays in the busy season of spring and autumn, and the pieces would be sold to the drapers who flocked to the warehouses. At one time the merchant or his representative rode over the country showing their patterns to the mercers, and the cloths were afterwards forwarded over the roads by the waggons of the carriers. The foreign trade was at the outset—some 240 years ago—founded by British merchants or their agents who travelled, but it was not very long before the representatives or members of foreign firms came and settled themselves in Manchester, and from that day to this they have steadily increased in number. At the present time great commercial houses from almost all the nations of the world are directly represented on the boards of the

SHIPPING COTTON AT NEW ORLEANS

Manchester Exchange on market days. The Exchange presents the busiest aspects on Tuesdays and Fridays, the principal market days, when the floor is crowded with principals and agents—spinners, manufacturers, bleachers, dyers and printers, machine makers, and representatives of all firms having direct or indirect connections with the cotton industry. The capital represented is stupendous. Yarn and cloth agents are very numerous. The yarn agent finds the customer for the spinner from whom he receives his commission. Every firm is directly represented on the market and very many have their own Manchester warehouse and offices, some on a very large scale. Some of the most influential cotton spinning and manufacturing firms are merchants also, and send their travellers out to all the towns and cities of this kingdom and foreign nations. "The cloth market," says Chapman in his admirable work on *The Lancashire Cotton Industry*, "is far removed in character from the highly developed markets, since fabrics contain all the differences that exist between yarns, and, in addition, all those consequent upon the numerous operations conducted in the weaving shed. Yet we find a rough grading of certain classes of cloth, which the development of machinery is constantly rendering more perfect. Cloths purporting to be the same vary less now that the differences due to human skill have been minimised, and a great uniformity has been introduced in the working of power looms.

"The cloth market is somewhat the same as it was at the end of the eighteenth century. The grey cloth agent, whose function is analogous to that of the yarn agent, is a new feature and the Manchester warehouseman or shipper takes far fewer risks and stocks less in proportion to the business done than did his predecessor a century

ago." The export business in yarns and cloths is principally in the hands of shippers, but there is a certain number of firms who do their own marketing abroad. There is a decided line of difference between the home merchant and the shipping merchant dealing with foreign orders. "Selling through independent merchants' houses," says Chapman, "is to be expected when the commodities dealt in tend to be of sorts that sell themselves, that is, commodities more or less gradable, for which a private market need not be won. Lancashire manufacturers who push their own products over the heads of the merchants are those who produce special classes of goods and depend upon these goods earning and retaining a popularity of their own. When the goods to be sold have to make private markets or when they are complicated and require to be explained to would-be buyers by competent experts there is a tendency for manufacturers to attempt themselves to reach the consumers, or retailers, or the foreign agencies through which such goods can be sold."

CHAPTER VII

TRADE UNIONS

FROM the passing of the Combination Acts in 1799–1800 till their abolition in 1825, trade unions were, in the eyes of the law, illegal organisations, and the early Unions of the Cotton Operatives were founded amid great difficulties. On page 123 there will be found some very interesting excerpts from the rules of what was probably the first of the cotton spinners' Unions, established in Manchester in 1795. Preston was the cockpit for many of the early struggles as to wages. Spinners' associations were formed in Oldham and other centres, the Oldham Province being established in 1843 and developing into one of the most powerful trade unions in the country. In 1880 the Bolton Association of self-actor spinners united with the old hand-mule spinners' organisation of that town, and the neighbouring associations of cotton spinners and winders coming into line, there was established the Bolton Province. The Amalgamated Association of Operative Cotton Spinners of Lancashire and adjoining counties was constituted in 1853, but it did not become powerful until after 1870, when a new financial basis was laid down. A union of the Weavers of Great Britain and Ireland had been founded in 1840, when the Stockport strike took place, but this proved a very imperfect union. In 1854 the weavers of Blackburn became organised on a sound basis. Other associations were formed in Preston, Darwen, Accrington, Colne, Nelson, and other weaving centres; and in 1884 the various Operative Weavers' Associations became

federated in the Northern Counties' Amalgamated Association of Weavers. In 1830 the hands in the card and blowing rooms became organised, and they have grown into a powerful union. Other departments of the textile industry have their own associations and amalgamations.

The various branches of operatives are now closely linked for mutual aims, and by International Conferences are becoming sympathetically associated with the operatives of the Continent.

The present organisations of the operatives are the Amalgamated Association of Operative Cotton Spinners; Amalgamated Association of Card and Blowing Room Operatives; Amalgamated Northern Counties Association of Warpers, Reelers, and Winders; Amalgamated Power Loom Overlookers; Bleachers and Dyers; Society of Twisters and Drawers; Society of Cloth-lookers. Then there are the Amalgamated Associations of Slashers and Tapers, and other organisations.

The operatives' amalgamations appoint representatives to the Legislative Council of the Textile Workers' Association, which deals exclusively with legislative questions affecting the cotton industry. The various societies are also affiliated with the Trades Union Congress, and through it take a prominent part in Parliamentary questions.

There is also a Trades Federation for offensive and defensive purposes, composed in some towns, at any rate, of weavers, overlookers, slashers, cloth-lookers, twisters, and drawers. It is not within the scope of this work to refer to trade disturbance either by strikes or lock-outs, but the tendency on the part of both masters and men is in the direction of establishing enduring relationships of peace, based on equitable understandings.

Although the Trade Unions of England are, to some extent, a political organisation, their main purpose is the improvement of the working conditions in the mills, and of wages and hours of labour. Few masters will be found in Lancashire to-day who do not admit frankly that the Trade Union movement has been of great benefit to the industry as a whole. The Textile Trade Unions have not, as a rule, been aggressive or unreasonable in their dealings with the masters ; they have also shown that they can take long views of trade interests. Thus they have contributed liberally to the funds of the British Cotton Growing Association and have, in agreement with the Masters' Associations, enforced the systematic introduction of short time whenever the industry has been in difficulties owing to shortage of raw material or other causes. In conjunction with the masters, the Union officials have worked out standard lists of wages which greatly facilitate the working of the industry, and by means of collective bargaining both sides agree to fixed wages for certain periods. Thus unfair price-cutting between the masters is very much reduced. The Unions are very well organised, and only one case has occurred where the men refused to adhere to an agreement arrived at by the officials on their behalf.

The organisation of the employers is equally good, and representatives of the Employers' Federation are constantly meeting those of the Operatives' Associations. These meetings, including meetings between local officials as well as those of the Federation, will total up in any one year to well over 300. One of the most important pieces of work accomplished by the Federation and the Unions was the settlement arrived at in the year 1893, known as the Brooklands Agreement. This was adopted after a stoppage of the Federation

mills, which lasted twenty weeks, arising out of a demand by the employers for reduction of wages on account of the state of trade. This broad and statesmanlike agreement was the means of preventing scores of strikes—only one general strike, which lasted seven weeks, has taken place during the last twenty years—but it has now been rescinded.

A word may here be added as regards the Continental Trade Unions. They make politics their foremost aim and trade improvements secondary. Only on rare occasions will the masters admit collective bargaining; and this may be partly attributed to the fact that the conditions of the industry vary greatly, the industry being less specialised and more scattered than in England, with consequent varying conditions of cost of living, etc.

The following is an interesting historical document showing the rules and regulations of probably the first Cotton Spinners' Trade Union, established in Manchester in 1795.

ARTICLES, RULES, ORDERS, AND REGULATIONS MADE AND TO BE OBSERVED BY AND BETWEEN THE MEMBERS OF THE FRIENDLY ASSOCIATED COTTON SPINNERS WITHIN THE TOWNSHIP OF MANCHESTER IN THE COUNTY OF LANCASTER, AND IN OTHER TOWNSHIPS AND PLACES IN THE NEIGHBOURHOOD THEREOF; ESTABLISHED THE 31ST DAY OF JANUARY, IN THE YEAR OF OUR LORD, 1795, AT THE THREE HORSE-SHOES IN THE MARKET-PLACE, MANCHESTER.

PREAMBLE.

Whereas the Township and Neighbourhood of Manchester contain a great number of Cotton Spinners, many of whom have settlements in distant parts, and when afflicted with sickness, or other misfortunes, cannot obtain relief without bringing a charge and burden on the inhabitants of the respective township, and places wherein they reside; and then only a small allowance, insufficient to support themselves and families;

it is therefore agreed amongst them to form a society, in order to raise a fund for the maintenance of such as shall hereafter be in distress, and to defray the funeral expenses of those who may die members of this society.

EXCERPTS FROM THE RULES.

XV.

That no member of the said society shall instruct any person in the Spinning of Cotton (except his own children, and paupers who may receive relief from overseers) until such person shall have paid the sum of one guinea to this society, exclusive of his entrance money and weekly subscription as aforesaid.

XVII.

That if any member or members, after having received his, her, or their wages, shall in a boasting manner (as hath frequently been the case) acquaint different people not being members of this society, what money they have earned in a short time (which has often been very injurious to Cotton Spinners), such person so offending shall forfeit two shillings to the fund, to be paid to the collecting member of the shop where such person shall work, who shall report such misbehaviour to the committee for the time being; and if such offending member shall refuse or neglect to pay such fine after seven days' notice, he shall be excluded all benefit arising from the society.

XVIII.

That if any member shall fall sick, blind, or lame, and thereby become incapable of working, he shall on making known his infirmities, provided they are not such as are brought upon him, or her, by his, her, or their own intemperance, or debauchery, be paid the sum of five shillings and six pence per week during one whole year, in case his infirmities so long continues, or more or less, at the discretion of the arbitrators for the time being, if they find his, her, or their situation may require, but if the member continues sick any longer he shall be paid the sum of three shillings and six pence, so long as he may continue sick, more or less, as the arbitrators for the time being may think proper; but no person shall be entitled to any relief till he shall have been a member of the society for one calendar month; and if any such member happen to be out of work (provided it be not through any default, or misconduct of himself) he shall receive such relief from the society for the time he, she, or they shall be out of employ, as in the direction of the arbitrators

for the time being, shall be deemed sufficient ; and that in case any member being so relieved, shall be suspected of deceit in his infirmities, the arbitrators for the time being, shall be at liberty to call in some skilful physician to examine the member, who, if he shall refuse to be examined, or if upon such examination, on the report of such physician it shall appear that such member shall have imposed upon the society, he shall be excluded any further benefit therefrom, nor shall he ever again be re-admitted.

XIX.

That in case of the death of any member or members of this society, his or their widow, or widows, or his, her, or their next of kin, shall receive from the fund of this society the sum of five guineas for the funeral expenses of such deceased member or members, more or less, at the discretion of the arbitrators for the time being.

XXV.

That if any person or persons belonging to the said society, shall assault or abuse any master, or other person employed as foreman, or manager, in the business of Cotton-Spinning, or shall do any wilful or voluntary damage to their houses, buildings, or property, on any pretence whatsoever, or shall combine together to raise the price of their wages, contrary to law ; or shall make any riot or disturbance against the public peace, or shall disobey any summons or order of any of his Majesty's Justices of the said county ; or be found guilty of any criminal offence whatsoever ; each person or persons shall be immediately expelled from this society, and not partake of the advantages hereby intended for the encouragement of sobriety, industry, and peaceable behaviour ; and every member of the said society doth hereby agree to observe, and strictly perform all the articles herein contained, so that peace, harmony, love, and friendship may be preserved between them, and their families, and that the Cotton Manufactory may thereby flourish and increase.

CHAPTER VIII

MASTERS' ORGANISATIONS

THE cotton employers of various districts took early concerted action for the protection of their mutual interests, and each cotton spinning and manufacturing[1] centre has its Masters' Association to-day. These have become amalgamated and federated into two very powerful bodies. The principal organisations to-day are the Federation of Master Cotton Spinners' Associations, and the Cotton Spinners' and Manufacturers' Association (formerly known as the N. and N.E. Lancashire Master Cotton Spinners' and Manufacturers' Associations), one representing the spinning section of the industry, as well as about 80,000 looms; the other the weaving section and about 4,500,000 spindles, situated mostly in N. and N.E. Lancashire.

Twenty-five years ago, most towns possessed a Masters' Association. Oldham became the most important, on account of the large number of spindles located there; but it was at length felt by the employers that it was no longer possible for disputes, etc., to be dealt with satisfactorily by one Association, however large. It was, therefore, decided to form an amalgamation; and in February, 1892, the now famous Federation of Master Cotton Spinners' Associations was established with a membership of seven districts, and embracing firms owning 17,000,000 spindles. Now it includes thirteen districts and 45,000,000 spindles.

The Federation is the highest tribunal in case of

[1] Whilst in the U.S.A. manufacturing of cotton includes spinning as well as weaving, in England manufacture of cotton is somewhat illogically, confined to weaving.

disputes. Any question between employers and workmen is first submitted for decision to the local association to which the mill in question belongs, and, if no agreement can be arrived at, the case is submitted again to a committee of the Masters' Federation at Manchester. No strike is allowed to take place without first being discussed locally and again by the Central Organisation. The Federation has its own Workmen's Accident Insurance and Mill Fire Insurance Organisation, and questions of Parliamentary legislation affecting the cotton trade and other problems, such as the handling of cotton bales, cotton and yarn contracts, etc., are constantly dealt with by special sub-committees.

The Cotton Spinners' and Manufacturers' Association is on similar lines. It is the dominating factor in the settlement of disputes relating to weaving. Whatever the Federation of Master Cotton Spinners' Associations decides as regards wages in the spinning section of the industry, is automatically followed by those members of the other Masters' Association who have spinning as well as weaving mills ; whilst any modifications decided upon in the weaving wages by the Cotton Spinners and Manufacturers' Association is likewise adopted by the weaving mills in the Federation.

In 1904, the year of Sully's successful but short-lived " corner " of the raw cotton supply, the Federation introduced an organised short-time movement ; the working hours were reduced from 56 to 40 per week, the idea being that it would be better for the workpeople to have some employment all the year than full-time working for a period and no work at all for a considerable period. Such an organisation would, of course, react at once on the price of the raw material ; and it has been maintained that the short-time

movement introduced by the Federation smashed up the Sully "ring."

The members of the English Federation, however, recognised that England alone was unable to dominate the cotton position, as the United States and Continental countries were using larger quantities of cotton. It was, therefore, decided to call a conference of all the cotton-using countries with a view to discussing the essential problems of common interest to the whole industry. It was not considered fair that one country alone should make the sacrifices involved in short time, for example, and the others benefit equally by such action. After unsuccessfully approaching the British Government to invite representatives to such a conference, the English Federation proceeded to organise it on its own initiative, and the first International Conference took place at Zurich in May, 1904, an agreement having already been come to with the Swiss Master Cotton Spinners' and Manufacturers' Association. Nine nationalities were represented at this meeting, and it was recognised by all that there were many questions of common interest to the cotton industry throughout the world. The most important of these was and still is the production of an ample supply of raw material. It was recognised from the outset that it would be folly to take a narrow national point of view in regard to the supply of the raw material; and that no matter where any additional supply came from, it would be beneficial to the industry as a whole. It was finally decided to establish an International Federation of Master Cotton Spinners' and Manufacturers' Associations. This was to be a kind of international chamber of commerce specialised for the cotton industry. The English Federation being the most powerful, it was natural that the President

of that organisation (Sir Charles W. Macara, Bart.), who had taken an active part in the formation of the Federation, should occupy the chair of the International organisation ; but it was decided on England's proposition that every country should have an equal voice in the administration of the Federation's affairs.

Besides the question of the increased supply of the raw material, the International Federation has dealt with the building up of the organisation of Masters' Associations in other countries on the pattern of the English Federation ; it has endeavoured to bring about closer relations between the cotton planters and the users ; it acts as an International Intelligence Office in all cotton questions ; and at its conferences such questions as the handling of cotton, net cotton contracts, mill fire insurance, international boards of arbitration for the settlement of trade disputes, moisture in cotton, etc., have been discussed. The International Federation has also taken a very special interest in the possibilities of the extension of cotton cultivation in India, and the reports of the Secretary's visits to India indicate the manner in which that aim can be achieved.

The International Federation also supplied a long-felt want by collecting and publishing statistics of the half-yearly mill stocks of cotton and the yearly consumption of cotton throughout the world. Prior to the establishment of the International Federation, such statistics as existed on these points were largely guesswork ; but since 1906 the individual mills have made periodical returns to the Federation Offices at Manchester, and the statistics thus compiled are recognised all the world over as reliable.

The Annual Congresses of the Federation give members an excellent opportunity of exchanging opinions both publicly and privately on other trade matters, and

thus friendly relations amongst the nations are also fostered. Congresses have been held in the following cities : Zurich (1904), Manchester (1905), Bremen (1906), Vienna (1907), Paris (1908), Milan (1909), Brussels (1910), Barcelona (1911), and Scheveningen (1913). Under the auspices of the International Federation, deputations of more than 100 cotton spinners visited the American Cotton Belt in 1907, and the Egyptian cotton fields in 1912, and held Conferences with the cotton planters and merchants in these countries. The reigning heads of almost all the countries of Europe have received the committee in audience.

The International Federation has published most interesting reports of all the Congresses, and of the visits undertaken by the Secretary (Mr. A. S. Pearse) to India, Egypt, and the Anglo-Egyptian Sudan, which contain valuable descriptions of the chief cotton growing areas of the world. The distribution of these reports in English, French, and German throughout the whole industry, both in Europe and elsewhere, has done much to educate both the governments and the public of every country where cotton is grown or manufactured in regard to the world-wide importance and the complicated problems of the cotton trade. Every cotton-spinning country in the world, except the United States, is now affiliated to the Federation. Sir Charles W. Macara, Bart., remained President of the Federation until 1914.

The war has inevitably interfered with the activities of the International Federation, but it is certain that after the war there will be greater need than ever for the kind of work which the Federation has been doing in the past.

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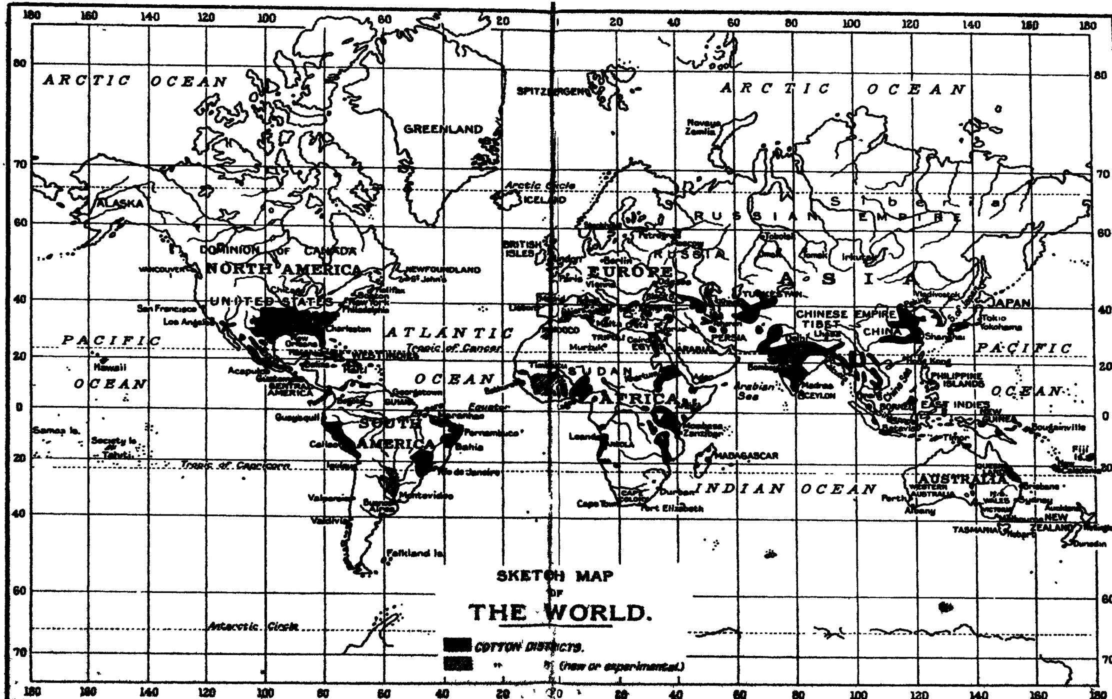

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